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EXPERIMENTS ON THE QUALITY OF TEA

BY

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During the manufacturing seasons of 1934 and 1935, experiments on the influence of manuring, plucking, and variety or *jat* of bush on the quality of the made tea, have been carried out. Previous to 1934 many experiments of less detailed and less accurate nature were done, but although much useful information was obtained, results could not be considered definite.

Within recent years, technique in connection with the arrangement of experiments so as to render the results obtained capable of statistical analysis, has been developed, particularly in the direction of field experiments in agriculture. It was found that this technique could be suitably applied to manufacture experiments, and an experimental design has been employed which has enabled us to assess the effect of factors apart from the one under investigation, which influence the value of the tea, and cannot be eliminated from the experiment.

The design employed in all experiments was the "Latin square" plan. In order to understand the reasons for employing this design, a knowledge of our method of manufacture is necessary.

The leaf samples were brought in to the withering shed about midday and spread, in turn, on bamboo racks covered with cloth, (which was always boiled each day before manufacture). Rolling started next morning at 4-0 A.M. in the hot weather experiments and at 6-0 A.M. during the cooler weather in October and November. Thus the leaf had a minimum of 16 hours wither. The leaf was spread on the withering chungs in the same order as that of rolling.

There are two rollers, designated East and West rollers. They are of the same type, but even when running at identical speeds and with the same pressure, do not produce identical effects, *i.e.* bruising and twisting action on the leaf.

The East roller, on account of slightly larger clearance between box and table, allows considerably more leaf to escape and be

ground up between the edge of the box and the table. This leaf is continually swept back, and the resultant effect is to cause more bruising and breaking up of the leaf.

The rolling system was :—1st roll of one hour, starting with 10 minutes no pressure and then alternately 10 minutes pressure and 5 minutes no pressure. The leaf was then dropped, balls broken up by hand, and the leaf returned to the same roller. The time occupied between stopping the 1st roll and starting the second was 5 minutes.

The second roll was for ½ hour with alternately 10 minutes pressure, and 5 minutes no pressure.

As the pressure cap is a wooden one about 20″ square and 5″ deep, and is not held down by any spring, the maximum pressure obtainable is not very great, small in fact, in comparison with that of the larger types of roller used in factories.

The dryer is a Single Tilting Tray Sirocco, divided in two equal portions so that two samples can be fired simultaneously.

Eight different treatments were under trial in all experiments except one, the *jat* experiment, in which only 6 different *jats* were under trial. Now supposing eight samples of leaf from plots which had had identical treatment are to be manufactured, the most convenient way is to roll, ferment and fire them in pairs, one of each pair in the East and one in the West roller. There would thus be 4 pairs of rolls, at 95 minutes intervals (allowing 90 minutes for each roll and 5 minutes for filling the roller).

One could therefore not expect to get eight identical teas from this manufacture. Firstly, the 4 teas rolled in the East roller might differ considerably from those rolled in the West roller, and secondly the four pairs of teas might differ according to the order in which they were rolled, since the second pair get 95 minutes, the third 190 minutes and the fourth pair 285 minutes longer withering than the first pair, and moreover, the later rolled teas are rolled and fermented usually at higher temperatures than those earlier rolled.

If, as in the case of our experiments, the eight samples of leaf are from plots differing in manuring, plucking, or some other way, the relative values of the resulting teas could not be expected to represent truly this treatment, but should be affected by the order in which the samples were rolled, or by the roller used.

When treatment is such as to produce very wide difference in the teas, as in the *Jat* or the Plucking experiment, the effect of a difference of 3 or 4 hours in withering, or of the different actions of the rollers, is to a great extent masked. When however, the treatment produces very much smaller differences as in manuring experiments, the effect of the rollers and the order in which the teas are manufactured shows up.

It is impossible to eliminate these outside factors, nor is it necessary to do so. By manufacturing the samples a sufficient number of times we can arrange for all the samples to occupy every position in the order of manufacture the same number of times and to be rolled an equal number of times in each roller. If the eight samples are all manufactured on eight occasions, each sample can be rolled 4 times in the East and 4 in the West roller; each sample can also occupy on two occasions, each of the first, second, third and fourth positions in order of rolling. (See table I. appendix).

It will at once be realised that this arrangement is not entirely satisfactory, since the order in which the teas are manufactured may not have the same effect on the tea, on each occasion of manufacture. For example, on a day when temperature is practically constant over the period of manufacture there may be little difference between the teas made early and those made later in the day. On a normal rains day when the fermenting room temperature at 6 A.M., is about 80°F. and at midday 90°F., one may expect a considerable difference between the first and last rolled teas.

If this daily temperature variation differs considerably on the different occasions of manufacture, then the variance due to order of manufacture (See appendix) may be smaller, and the variance due to "residual causes" (factors unaccounted for) will be greater, than if the temperature variation were the same on every day of manufacture.

The results of the experiment are not made less valid by this increase in residual variance, but, the error being greater, differences due to treatment may become less significant.

After the tea has been fired, it is cut by passing it through a Savage Cutter with ½" cells and then through the same cutter with ¼" cells. The dust and very small "fannings" are sifted out and comprise about 7% of the total bulk. The very coarse leaf, comprising about 6% of the total bulk is also sifted out. Thus the tea from which samples are taken for tasting and valuation and for analysis, comprises at least 85% of the original leaf manufactured.

This system of sorting has been adopted primarily because it was found to be almost impossible to sort small quantities into normal grades under identical conditions for each sample. Hand sorting would be necessary for dealing with samples of only 5 lbs. weight, and hand sorting is impossible to standardise. Moreover, the number of samples to be valued would be multiplied several times.

Tasters have all agreed that the sample representing 85% of the bulk is satisfactorily even, and as valuations are comparative, there would be little to be gained by grading, even if this could be carried out accurately.

In the case of all experiments except the one on plucking in 1934, the percentages of dust and of coarse tea were identical for all samples on any particular manufacture. In the case of the plucking experiment, it was expected that there would be much more coarse grade tea from the coarser plucked tea, and for this reason valuations were obtained both for the main bulk (labelled B. P.) and for very coarse tea (labelled Souchong). Actually, the variations in percentages were much less than anticipated, and the average valuations are very much the same whether or not allowance is made for the slight differences in percentages of coarse and fine tea. In the 1935 experiment, the normal method of sending only the B. P. grade for valuation was employed.

The tasters' valuations on the complete set of 64 samples can be subjected to the "Analysis of Variance" (Fisher), which is a

mathematical method of obtaining the variance, or effect on valuations, due to the treatments under trial, due to each of the other extraneous factors, and the residual variance which is that portion of the variance due to factors either not known, or not accounted for. From this residual variance, it can be calculated which differences are really significant and which may be due to chance only. In the following account of experimental results, the "significant differences" are calculated so that there is a 20 to 1 chance on any difference in average valuation between any two samples which is greater than the significant difference, being due actually to the difference in treatment and not to chance.

The method of calculating the variances and the significant difference is illustrated in an appendix to this article by an example taken from the 1934 plucking experiment.

The experiments described below are grouped as follows :—

I. Effect of manuring.

(*a*) Effect of quantity—(different quantities of inorganic manure mixture).

(*b*) Effect of quality—(comparison of nitrogenous manures in different forms, organic and inorganic)

(*c*) Effect of phosphoric acid and potash.

II. Effect of different styles of plucking.

III. Effect of variety of bush.

I. Effect of Manuring.

(*a*) *Effect of different quantities of complete inorganic mixture, in single and divided doses, on quality of second-flush teas.*

The leaf samples employed in this experiment, which extended over the 1935 "second flush" period, were obtained from 8 series, each consisting of 8 plots, on the Mesai Manipuri block of tea at Borbhetta. The manuring of the series has been in operation for 5 years, 1931 to 1935 inclusive.

Manures, in chemical form, were applied annually in quantities to give the amounts of nitrogen, phosphoric acid, and potash set out in the following table. When single doses were applied, the application was made at the end of March. In the case of divided doses, half the total quantity was applied in March (at the same time

as that of the single dose plots) while the second dose was applied at the end of June in three cases, series 5, 6, and 7, and at the middle of May in the case of series 8.

TABLE I.

Series.	Manuring treatment lbs. per acre.			Method of application.	1935 yields in mds. tea per acre up to 31st July.
	Nitrogen.	Phosphoric acid.	Potash.		
1	0	0	0	......	1·67
2	40	20	20	One dose, March	3·09
3	80	40	40	One dose, March	4·80
4	120	60	60	One dose, March	5·62
5	40	20	20	Two doses, March and June.	2·91
6	80	40	40	Two doses, March and June.	4·33
7	120	60	60	Two doses, March and June.	5·75
8	80	40	40	Two doses, March and May.	4·55

The teas were sent to 6 tasters in India and four in London who each placed their valuation on each of the 64 teas. The valuations for each of the eight teas were averaged for each of the 8 occasions of manufacture; the final analyses of variance being made on these averages.

The combined results of the Calcutta tasters are considered first.

TABLE II.

Average weekly valuations of 6 Calcutta tasters.

Valuations in annas and pies.

Manuring series.	JUNE.			JULY.					Average.
	4th	18th	25th	2nd	9th	16th	23rd	30th	
1	11-1·5	11- 2·7	11- 0·5	11-0·7	11- 1·0	10- 7·7	10- 8·8	10-6·2	10-11·1
2	11-1·5	11- 9·5	10-11·3	10-9·3	10- 3·8	10- 6·8	11- 0·2	10-6·5	10-10·6
3	10-8·5	11- 3·5	11- 3·2	10-4·7	10- 6·8	10- 4·8	10- 9·0	10-7·8	10- 8·9
4	11-0·3	11- 0·0	10- 9·3	10-7·3	10-10·2	9-11·0	10- 0·8	10-5·5	10- 7·1
5	10-5·0	11- 8·0	10- 5·0	10-9·2	11- 0·2	10- 6·8	10- 3·3	10-3·8	10- 8·2
6	10-5·5	11- 7·5	10- 1·7	10-5·8	10- 0·0	10- 2·0	10- 5·3	10-4·2	10- 5·5
7	11-1·0	10-10·5	10- 8·5	10-9·7	10- 4·7	10- 1·8	10-10·5	10-2·7	10- 7·7
8	10-5·0	11- 4·3	10- 4·0	10-8·5	10- 8·3	10- 5·2	10- 8·8	10-5·0	10- 7·6
Average	10-9·5	11- 4·2	10 -8·4	10-8·4	10- 7·4	10- 4·1	10- 8·6	10-5·2	10- 8·3
Significant difference in pies	...	—	0- 8·1	—	0- 6·1	—	0- 5·5	0-3·0	0- 3·0

The analysis of variance of the valuations in table II. is given below :—

TABLE III.

Analysis of variance of average valuations of 6 tasters.

(For Explanation See Appendix).

Variance due to	Sums of squares.	Degrees of freedom.	Mean squares.
Manuring	6904·19	7	986·31
Date of manufacture ...	26877·94	7	3839·70
Order of manufacture ...	2517·19	3	839·06
Roller action	2809·00	1	2809·00
Interaction of order and rollers	485·50	3	161·83
Residual causes ...	13624·12	42	324·38
TOTAL ...	53217·94	63	......

The difference required between any two of the average valuations for the whole experiment, which are given in the last column of table II. is given by the expression $\frac{\text{"t"} \sqrt{2} \sqrt{8} \sqrt{324.38}}{8}$

"t" for a 20 to 1 chance, and 42 degrees of freedom for residual variance is 2·02.

The significant difference therefore, obtained from the above expression is 3·02 pies.

The weekly averages show significant differences on four out of eight occasions. The manuring treatments on any particular date may be due to a combination of the three factors,—roller action, order of manufacture, and manurial treatment. In the final averages however the effect of rolling and order of manufacture

is eliminated, since each of these final averages is made up of valuations of teas which have twice occupied each of the four positions in order of rolling, and have been rolled 4 times in the East and 4 times in the West roller. The final averages then, represent difference due only to manurial treatment.

A difference of 3·02 pies is required for "20 to 1 on" chance of significance. On this basis, the teas from unmanured plots are significantly preferred to all except those from plots manured with 40 or 80 lbs. nitrogen in one dose, or 40 lbs. in two doses. The teas from the 40 lbs. nitrogen in one dose is significantly preferred to the tea from plots manured with 120 lbs. nitrogen in one dose, or 80 lbs. nitrogen in two doses (second dose in June).

The following table gives each taster's averages for the complete set of 64 teas which he valued.

Table IV.

Individual average valuations of 6 Calcutta tasters.

Valuations in annas and pies.

Manuring treatment lbs. per acre. N	P	K	Method of application	Tasters. A	B	C	D	E	F
0	0	0	...	11- 0·7	10-0·0	10-6·6	10-10·1	10-11·4	12- 1·9
40	20	20	one dose in March	10- 9·7	10-2·7	10-4·1	10-11·2	10- 8·9	12- 3·0
80	40	40		10-10·4	10-3·9	10-3·7	10- 6·7	10- 7·2	11- 9·0
120	60	60		10-10·4	10-2·1	10-2·2	9-10·5	10- 7·1	11-10·5
40	20	20	2 doses, March and end of June	11- 2·9	10-0·5	10-0·1	10- 1·5	10-11·0	11- 8·2
80	40	40		10- 8·4	9-9·2	9-9·6	10- 0·1	10- 8·2	11- 9·4
120	60	60		11- 0·0	10-1·5	10-0·0	10- 2·0	10- 8·0	11-10·5
80	40	40	2 doses, March and mid-May	10- 8·9	9-7·7	10-6·0	10- 1·4	10- 9·7	12- 1·1
Average			... ...	10-10·9	10-0·5	10-2·4	10- 3·9	10- 9·0	11-11·2
Significant difference in pies			...	...	...	...	7·34	2·87	...

Two only of the 6 tasters find significant differences due to manurial treatment. Taster D. makes nil and 40 lbs. nitrogen in one dose significantly better than 120 lbs. nitrogen in single or

divided doses, both sets of 80 lbs. nitrogen in divided doses, and 40 lbs. nitrogen in the divided dose. Tea from plots getting 120 lbs. nitrogen in one dose is also significantly worse than that from 80 lbs. nitrogen in one dose.

Taster E makes the tea from unmanured plots significantly better than all except 40 lbs. nitrogen in two doses, and 80 lbs. in 2 doses (2nd. dose in May). The 40 lbs. nitrogen in 2 doses is also preferred significantly to 80 or 120 lbs. nitrogen in single doses and 120 lbs. nitrogen in the divided dose.

The results of the London tasters are as follows :—

TABLE V.

Average weekly valuations of four London Tasters in pence.

Manuring series.	Dates of manufacture.								Average.
	June			July					
	4th	18th	25th	2nd	9th	16th	23rd	30th	
1	14·4	14·0	13·7	14·0	14·6	14·4	14·7	15·5	14·43
2	16·1	13·6	13·6	13·5	13·8	13·9	15·2	14·4	14·28
3	14·5	13·3	13·5	13·6	13·8	14·2	14·5	15·1	14·06
4	15·0	13·4	13·6	13·6	14·3	13·5	13·5	14·1	13·89
5	14·8	13·7	13·8	13·2	14·2	15·6	14·6	15·0	14·36
6	14·7	13·2	13·6	13·3	13·6	15·1	14·4	14·3	14·08
7	14·9	13·4	13·5	13·5	14·4	13·4	14·3	14·4	13·98
8	14·2	13·1	13·4	13·3	14·5	14·2	15·0	14·6	14·05
Average	14·8	13·5	13·6	13·5	14·2	14·3	14·5	14·7	14·14

Significant difference = $0{\cdot}33d$.

The average results of the four London tasters show unmanured teas as being significantly preferable to teas manured with mixtures supplying 80 lbs. or 120 lbs. nitrogen per acre, whether applied as one dose in March or when half is applied in March and the other half in May or June. The application of only 40 lbs.

nitrogen, in single or divided dose, has produced teas not significantly poorer than unmanured teas, but significantly better than teas from plots which had 120 lbs. nitrogen in one dose in March; the divided dose of 40 lbs. nitrogen produces teas which are also significantly better than those which had 120 lbs. nitrogen in two doses, one in March and the other in June.

These results are substantially in agreement with the Calcutta tasters opinions.

The individual results of the London Tasters are given in Table VI.

TABLE VI.

Individual valuations of 4 London tasters in pence.

Manuring lbs. per acre. N P K	Method of application.	Tasters. H	J	K	L	Average.
0 0 0	...	14·8	12·8	14·0	16·1	14·43
40 20 20	one dose in March	14·3	12·8	14·2	15·8	14·28
80 40 40	one dose in March	14·4	13·0	13·8	15·1	14·06
120 60 60	one dose in March	14·5	12·6	13·5	15·0	13·89
40 20 20	two doses March and end of June.	14·2	13·1	13·9	16·1	14·36
80 40 40	two doses March and end of June.	14·1	13·1	13·9	15·2	14·08
120 60 60	two doses March and end of June.	14·0	13·1	13·8	15·0	13·98
80 40 40	two doses, March and mid-May.	14·1	12·6	14·2	15·4	14·05
	Average ...	14·30	12·90	13·91	15·46	14·14

Tasters H, J and K make no significant differences between any of the 8 teas. Though the differences between best and worst teas are 0·8*d*. for taster H and 0·7*d*. for tasters J and K, the agreement between valuations of the eight successive sets of teas which

they valued, is not close enough to render any differences in their final averages significant.

Taster L gets better agreement between his eight sets of valuations, and his results do show significant differences. His significant difference is 0·72*d*. He thus places the unmanured teas and those manured with 40 lbs. nitrogen in single or divided doses, all significantly better than the teas manured with 80 lbs. nitrogen in a single dose and 120 lbs. nitrogen in single or divided doses. The unmanured teas, and those manured with 40 lbs. nitrogen in the divided dose, are significantly preferred to teas manured with 80 lbs. nitrogen in the divided dose, (applied half in March and half in either May or June).

An idea of the effect of quantity of nitrogen on quality can be obtained by averaging all valuations for teas from plots manured with the four levels of nitrogen, combining single and divided applications. These are given below, for Calcutta and London tasters :—

Quantity of nitrogen lbs. per acre.	Valuations.	
	Calcutta annas and pies.	London pence.
nil	10-11·1	14·43
40	10- 9·4	14·32
80	10- 7·3	14·06
120	10- 7·4	13·94

The above averages have been obtained from the final columns of tables II. (Calcutta tasters) and V. (London tasters).

Only one set of 8 teas from unmanured plots was manufactured. The above averages for these teas are therefore the same as those in the tables. For 40 and 120 lbs. nitrogen there are 16 valuations available while for 80 lbs. nitrogen there are three sets of eight, *i.e.*, 24 valuations.

By combining in this way the valuations of all teas which have had the same *amounts* of nitrogen, the required significant difference when comparing any two sets, becomes less than it was when the averages of only 8 sets of teas were being compared.

The significant differences required are as follows :—

Comparing nil and 40 lbs. N : Significant difference = 2·45*p*. (Calcutta) = 0·27*d*. (London).

The actual difference is only 1·7 pies for Calcutta valuations, and 0·11*d*. for the London valuations.

It must be concluded that there has been no significant loss in quality from the application of a mixture supplying 40 lbs. nitrogen and 20 lbs. each of potash and phosphoric acid.

Comparing nil and 80 lbs. N : Significant difference = 2·11 pies (Calcutta) = 0·23*d*. (London).

The actual differences are 3·8 pies (Calcutta) and 0·37*d*. (London). Thus 80 lbs. nitrogen (with 40 lbs. each of potash and phosphoric acid) is sufficient to reduce slightly, but significantly, the quality of the tea made. The valuations for the 120 lbs. dose of nitrogen are not significantly lower than those for 80 lbs.

Comparing 40 lbs. N. with 80 lbs. N : Sig. Diff. = 1·90 pies (Calcutta) = 0·21*d*. (London).

Both Calcutta and London significantly prefer the teas from the lighter application of manure.

(b) Effect of Nitrogen in different forms, Organic and Inorganic.

The leaf for this experiment was obtained from two adjoining blocks of tea at Borbhetta. Both were planted in 1921 from the same nursery of Tingamira (light leaf Assam) variety. One block, on which the effects of various nitrogenous manures are being compared, was medium pruned at 18″ in 1924 while the other block, devoted to comparison of the effects of various quantities of cattle manure on yield, was collar pruned at the same time, and the cattle manure block has always been slightly the better since

planting in 1921. Thus although check plots of both blocks have had identical treatment since 1924, they cannot, in view of the different pruning and slightly different soil, be assumed without proof to be giving the same quality leaf even at the present time. For this reason the unmanured check plots of each block were included in the experiment.

Eight samples of leaf were manufactured on each of eight occasions during June and July, and again on eight occasions during October, November and December, in 1934.

The manurial treatments of the plots from which the eight samples of leaf were taken, and their yields in 1934, were as follows :—

TABLE VII.

Manuring.	Mds. tea per acre.	
1. Unmanured "a" ...	6·58	from the block which was medium pruned in 1923 and since top pruned.
2. Sulphate of ammonia	11·61	
3. Calcium cyanamide	11·15	
4. Oilcake ...	10·07	
5. Blood meal ...	11·05	
6. Horn meal ...	11·26	
7. Unmanured "b" ...	7·67	from the block which was collar pruned in 1923, and since top pruned.
8. 5 tons cattle manure	10·33	

These treatments with the exception of No. 8 had been applied annually for 2 years previous to the experimental manufacture, in quantities to supply 60 lbs. nitrogen per acre per annum. The cattle manure application had been made three times in the previous four years.

The results of the experiment are considered first for the second flush period, in which four tasters in India gave complete

valuations, while incomplete results were obtained from three London tasters: secondly for the autumnal period, when five sets of valuations were obtained from tasters in India and three complete and one incomplete from London.

TABLE VIII.

Average weekly Calcutta valuations for "second flush" period.
Averages of 4 tasters' valuations in annas and pies.

MANURE.	DATES OF MANUFACTURE.								Average.
	JUNE.				JULY.			AUG.	
	8th	15th	22nd	29th	13th	20th	27th	4th	
Nil A ...	11-11·0	11-0·7	10- 8·4	11- 9·6	11- 7·9	11- 9·6	11-10·5	10- 8·2	11-5·2
Nil B ..	11- 7·7	10-1·1	11- 5·5	11- 4·6	12- 0·7	11- 3·7	11- 3·0	10- 6·5	11-3·9
Oilcake ...	11- 6·6	11-5·6	11- 1·2	11-11·7	11- 7·5	11- 6·0	11-11·7	10- 7·0	11-5·7
Blood meal	12- 0·0	11-2·0	11- 1·2	11- 9·0	11- 7·4	11-10·2	11- 2·2	10-11·0	11-5·4
Horn meal	11- 6·9	11-8·2	11- 8·9	11-10·2	11- 9·5	10-11·2	11- 9·2	10-11·0	11-4·9
Cattle manure ...	12- 3·0	11-4·2	11- 0·0	11-10·5	11- 7·7	11- 4·0	11- 6·0	10- 6·6	11-5·3
Sulphate of ammonia	12- 0·9	11-8·2	11- 0·6	11- 4·7	11-11·4	11- 2·4	11- 9·2	10- 6·2	11-5·5
Calcium cyanamide	11- 7·5	11-0·9	10- 7·5	11-11·2	11- 8·7	11- 4·6	11- 5·7	10- 8·7	11-3·5
Average ...	11- 9·9	11-3·6	10-11·7	11- 9·0	11- 9·1	11- 1·9	11- 7·2	10- 9·2	11-5·0

Analysis of variance valuations of 4 tasters.

Variance due to	Sums of squares.	Degrees of freedom.	Mean squares.
Manuring	2249·61	7	321·37
Date of manufacture ...	87238·36	7	12462·62
Order of manufacture ...	8108·30	3	2702·76
Roller action	3645·14	1	3645·14
Interaction of order and rollers	3815·42	3	1271·81
Residual causes	16033·90	42	381·73
TOTAL ...	121090·73	63	

The mean square of residual variance is actually larger than that for manuring, thus indicating that manuring in different forms has made no significant difference to the value of the teas.

The average individual valuations of each of the four tasters in India, and the average of all four together, is given below :—

TABLE IX.

Individual tasters' valuations in annas and pies, for "Second flush" teas.

Kind of manure.	Tasters.				Average of all 4 tasters.
	A	B	C	D	
No manure A. ...	11-10·0	11- 0·9	10-9·3	11-2·6	11-5·2
No manure B. ...	11- 9·0	11-10·5	10-7·7	11-0·1	11-3·9
Oilcake	12- 2·5	11- 8·5	10-9·4	11-2·3	11-5·7
Blood meal ...	11-10·0	11-11·1	10-9·4	11-3·0	11-5·4
Horn meal ...	11- 8·0	11- 9·4	10-8·9	11-5·2	11-4·9
Cattle manure ...	12- 0·0	11-11·6	10-8·9	11-1·3	11-5·3
Sulphate of ammonia ...	12- 1·0	11-10·9	10-8·6	11-1·4	11-5·5
Calcium cyanamide ...	11- 6·0	11- 9·6	10-8·7	11-1·6	11-3·5
Average ...	11-10·3	11-10·3	10-8·9	11-2·2	11-5·0

None of the four tasters makes significant differences due to different forms of manuring.

The teas were sent also to three London brokers, but only 7 out of the 8 sets were valued. Thus the results are not capable of statistical examination to the same degree of accuracy as those of the Calcutta brokers. The average valuations of 7 sets are given however, for each of the three tasters.

TABLE X.

London tasters' valuations in shillings and pence, for "Second flush" teas.

KIND OF MANURE.	TASTERS. H	TASTERS. J	TASTERS. K	AVERAGE.
No manure A ...	1–2·6	1–0·8	1–2·1	1–1·8
No manure B ...	1–2·5	1–1·5	1–2·1	1–2·0
Oilcake	1–3·3	1–1·2	1–2·6	1–2·4
Blood meal	1–3·1	1–1·2	1–2·7	1–2·3
Horn meal	1–3·0	1–1·2	1–2·2	1–2·2
Cattle manure ...	1–2·2	1–0·7	1–2·1	1–1·7
Sulphate of ammonia ...	1–3·1	1–1·9	1–2·5	1–2·5
Calcium cyanamide ...	1–3·5	1–1·5	1–2·8	1–2·6
AVERAGE ...	1–2·8	1–1·3	1–2·7	1–2·2

There is certainly no indication that unmanured teas are preferable to the manured teas, or that the teas manured with organic manures are preferable to those manured with inorganic manures.

The experiment was repeated during the late rains and autumnal period *i.e.* October and November. Valuations were obtained from 5 Calcutta brokers and from 4 London brokers.

TABLE XI.

Average Weekly Calcutta valuations in annas and pies, for "Autumnal" teas

Manuring treatment.	DATES OF MANUFACTURE. October. 5th	October. 12th	October. 19th	October. 26th	November. 2nd	November. 16th	November. 27th	Dec. 11th	Average.
Nil A. ...	9- 6·2	9-9·2	9-8·6	9-8·4	10-9·6	10-7·8	11- 0·0	12-10·4	10-6·0
Nil B. ...	9- 8·6	9-8·0	9-5·8	9-9·2	10-4·8	10-9·0	11- 5·8	12- 5·6	10-5·6
Oilcake ...	9- 7·8	9-8·6	9-6·8	9-9·8	10-3·6	10-4·2	11- 3·6	12- 7·4	10-5·0
Blood meal	9- 9·0	9-7·8	9-7·8	9-9·2	10-5·8	10-7·0	11- 4·6	13- 3·6	10-6·9
Horn meal	9- 8·8	9-7·2	9-8·4	9-7·6	10-4·2	10-1·8	11- 1·0	12- 2·8	10-3·5
Cattle manure	9- 8·8	9-6·6	9-5·8	9-9·4	10-0·8	10-4·4	10- 9·8	12-11·8	10-4·2
Sulphate of ammonia.	9-11·2	9-6·4	9-7·6	9-7·8	10-7·4	10-2·6	10-11·8	12- 3·2	10-4·3
Calcium cyanamide	9- 7·8	9-7·4	9-8·0	9-9·2	10-6·6	10-9·4	11- 4·0	12- 3·8	10-5·3
Average ..	9- 8·5	9-7·6	9-7·3	9-8·8	10-5·1	10-5·8	11- 1·8	12- 7·2	10-5·1

The analysis of variance shows that variance due to treatment is small compared with the residual variance and the differences between the average valuations for the different forms of manuring are not significant.

The individual results for each of the 5 tasters in Calcutta are given below.

TABLE XII.

Individual valuations of 5 Calcutta Tasters for "autumnal" teas.

Manuring treatments.	Tasters.					Average.
	A.	C.	E.	F.	G.	
No manure A ...	9·9·4	10·9·0	11·7·1	10·0·9	10·3·9	10·6·0
" " B ...	9·8·1	10·10·2	11·6·4	10·1·0	10·2·2	10·5·6
Oilcake	9·9·1	10·6·7	11·6·0	10·1·0	10·2·0	10·5·0
Blood meal ...	9·8·4	11·2·1	11·6·5	10·1·5	10·3·8	10·6·9
Horn meal ...	9·4·9	10·4·4	11·5·8	10·0·4	10·2·0	10·3·5
Cattle manure ...	9·5·6	10·6·1	11·6·4	9·11·1	10·5·5	10·4·2
Sulphate of ammonia ...	9·5·4	10·6·7	11·5·1	10·1·0	10·2·5	10·4·3
Calcium cyanamide ...	9·4·9	11·0·0	11·5·0	10·0·4	10·4·1	10·5·3
Average ...	9·7·0	10·8·8	11·6·1	10·0·8	10·3·0	10·5·1

Again none of the tasters makes any significant difference between teas manured with different forms of nitrogen.

The average valuations of three London tasters are now considered. Valuations from Taster H were given on only 7 out of the 8 sets of tea. From his results no variances for roller action or order of rolling can be extracted, so that, although his results show significant differences, they must be regarded with caution. His average valuations were as follows :—

Average valuations of taster H on 7 sets of "autumnal" teas.

Manure.	Valuations. *s. d.*	Manure.	Valuations. *s. d.*
No manure A ...	1-1·9	Horn meal ...	1-2·4
No manure B ...	1-1·8	Cattle manure ...	1-0·9
Oilcake ...	1-2·2	Sulphate of ammonia	1-2·2
Blood meal ...	1-1·6	Calcium cyanamide ...	1-2·9

The significant difference is 0·84*d*; he therefore prefers the tea manured with cyanamide to any except those manured with oilcake, horn meal or sulphate of ammonia. The teas manured with cattle manure are valued significantly lower than all except the unmanured (*a*) and blood meal teas. The results of the three tasters who gave full valuations are as follows :—

TABLE XIII.

Average Weekly London valuations in shillings and pence on "Autumnal" teas.

Manuring treatments.	Dates of Manufacture.								Average.
	October.				November.			Dec.	
	5th	12th	19th	26th	2nd	16th	27th	11th	
No manure A ...	1-1·2	1-0·8	1-0·7	1-1·0	1-0·8	1-0·1	1-0·7	1-1·7	1-0·89
No manure B ...	1-1·7	1-1·2	1-0·4	0-11·9	1-1·1	1-0·4	1-0·7	1-1·7	1-0·78
Oilcake ...	1-1·3	1-0·1	1-0·7	1-0·5	0-11·9	1-0·9	1-1·1	1-0·9	1-0·71
Blood meal	1-0·0	1-0·0	1-0·4	1-0·0	1-0·4	1-0·9	1-0·7	1-2·1	1-0·56
Horn meal	1-1·2	1-0·2	1-0·5	1-0·7	1-0·3	1-0·8	1-1·4	1-0·8	1-0·72
Cattle manure	1-0·0	1-0·8	0-11·8	1-0·5	1-0·2	1-0·0	1-0·2	1-0·7	1-0·31
Sulphate of ammonia...	1-1·2	1-1·2	1-0·4	1-0·7	1-0·4	1-0·0	1-1·3	1-0·7	1-0·74
Calcium cyanamide	1-0·6	1-1·5	1-0·6	1-0·7	1-0·4	1-0·6	1-1·4	1-1·5	1-0·90
Average ...	1-0·8	1-0·7	1-0·4	1-0·5	1-0·5	1-0·5	1-0·9	1-1·3	1-0·70

Analysis of variance.

Variance due to	Sums of squares.	Degrees of freedom.	Mean squares.
Manuring	305·24	7	43·61
Date of manufacture ...	724·11	7	103·44
Order of manufacture ...	55·80	3	18·60
Roller action	92·64	1	92·64
Interaction of order and rollers	3·92	3	1·31
Residual causes ...	1109·53	42	26·41
TOTAL ...	2291·24	63	......

The mean square of variance due to manuring must be about 2½ times that for residual variance in order that any valuation due to treatment difference shall be significantly different from any other. See appendix page 56.

The mean square of manuring variance is only about 1½ times the residual variance, and thus it must be concluded that the three London tasters are in agreement with the five Calcutta tasters in being unable to detect any significant difference in quality resulting from the use of different forms of nitrogenous manure, organic or inorganic; and further, have failed to find any preference for unmanured tea as compared with tea manured with the equivalent of 60 lbs. per acre of nitrogen.

The individual results of the three London tasters are as follows, each valuation being the average of the particular tasters' own valuations of 8 samples manured in the same way.

TABLE XIV.

Individual valuations in shillings & pence of three London Tasters on "Autumnal" Teas.

Manuring.	Tasters.			Average.
	J	K	L	
Manure A	1-1·0	1-0·6	1- 1·0	1-0·9
Manure B	1-1·1	1-0·8	1- 0·5	1-0·8
Oilcake	1-1·0	1-1·0	1- 0·2	1-0·7
Blood meal	1-0·7	1-0·7	1- 0·3	1-0·6
Horn meal	1-1·0	1-1·0	1- 0·2	1-0·7
Cattle manure ...	1-0·7	1-0·4	0-11·8	1-0·3
Sulphate of ammonia ...	1-0·9	1-1·0	1- 0·3	1-0·7
Cal. cyanamide ...	1-1·2	1-0·9	1- 0·5	1-0·9
Average ...	1-0·9	1-0·8	1- 0·4	1-0·7

Individually, none of the 3 tasters makes any significant differences between his average valuations of teas manured with different kinds of nitrogenous manure.

(c) The effect of Phosphoric Acid and Potash on Quality.

It has always been guessed, though without definite evidence, that "balanced" manuring is necessary in order to maintain quality. By a "balanced" manure is usually meant one which supplies the important plant foods,—nitrogen, phosphoric acid and potash, in such proportions as are required to maintain an adequate supply of these constituents to the plant, in available form.

For soils containing a high percentage of available phosphoric acid and only normal or low in potash and nitrogen, a balanced mixture would be one containing nitrogen and potash with little or no phosphoric acid. On a "grazing land" soil, (like that at Borbhetta on which the leaf for these manufacture experiments was grown,) which is very low, by analytical tests, in nitrogen and available potash and phosphoric acid, a balanced manure would be expected to be one containing all three constituents.

With the object of determining the individual and collective effects of these three plant foods on both crop and quality, experiments have been in progress at Borbhetta for a number of years. As far as crop is concerned, both potash and phosphoric acid have had little effect on yield, thus indicating that there is enough of these constituents in the soil, to supply the needs of the bush. At the same time, though the bushes on the plots getting nitrogen only, do not seem either in appearance or in productive capacity, to be suffering any shortage, the quality of leaf produced might be suffering from lack of either mineral.

In 1932, leaf from plots manured with nitrogen, phosphoric acid and potash in different combinations, was manufactured several times throughout the season. None of the experiments was designed on a plan which allowed of the results being statistically examined, and no valuations were obtained from the tasters, who simply gave their opinions on the relative characteristics of the liquors.

Nevertheless the results are of interest and may be summarised as follows :—

1. During June and July leaf was manufactured separately on four occasions from the plots manured as below :—

MANURE LBS. PER ACRE.

	Nitrogen.	Phosphoric acid.	Potash.
A	40	0	0
B	40	60	0
C	40	0	60

On each of the four occasions each of two tasters picked out B (with phosphoric acid) as superior in quality and flavour to either of the others, valuations being very roughly estimated at from 2*d*. to 4*d*. higher. One taster on each occasion picked C as more pungent than the other two, but did not always like it on that account, pungency appearing to mask flavour.

During this period when the "green-fly stunt" was severe, and crops were about 40% less than in the previous season, all the teas made were of very good "second flush quality", with flavour.

2. During the remainder of the season, leaf was separately manufactured on 11 other occasions.

Teas from leaf manured as below were compared.

MANURE LBS. PER ACRE.

	Nitrogen.	Phosphoric acid.	Potash.
On eight occasions :—			
A	40	0	0
B	40	60	0
C	40	0	60
D	40	60	60
On two occasions :—			
A	40	0	0
B	40	15	0
C	40	30	0
D	40	60	0
On one occasion :—			
A	40	0	0
B	40	0	30
C	40	0	60

On all 11 occasions reports were to the effect that differences were slight. Samples were sent to as many as five tasters but no two ever agreed on the order of preference. In October and November when autumnal character appeared (although the teas never showed stand-out flavour) there was some measure of agreement on preference for the "quality" of teas manured with phosphoric acid, but their superiority, if any, was slight. There was also some measure of agreement on preference for "thickness and body" of tea manured with potash, but here again indications were indefinite.

In 1933 experiments were better designed but were still not of the same degree of accuracy as those carried out in 1934. Valuations were obtained in most cases, but as these were incomplete, a method of assessing the relative order of merit of the teas was relied on. A complete account of the experiments appears in the Annual Report of the Scientific Department for 1933.

The leaf from 4 sets of plots, manured according to the following plan, was manufactured 12 times during the 1933 season.

Series.	Manuring lbs. per acre.			Marked as
	Nitrogen.	Phosphoric acid.	Potash.	
1	40	0	0	N
2	40	0	60	NK
3	40	60	0	NP
4	40	60	60	NPK

There were 4 occasions of manufacture in the second flush period, 4 in the rains and 4 in the autumnal period. The average valuations obtained for each set of 4 is given below :—

Manuring.	Valuation in annas.			
	Second flush.	Rains.	Autumnal.	Average over whole season.
N.	12·5	11·6	11·4	11·8
N. K.	13·3	11·35	11·15	11·9
N. P.	13·4	12·1	11·5	12·3
N. P. K.	13·75	11·9	11·3	12·3

The above are averages of three tasters' valuations in each case.

The season 1933, in marked contract to 1932, was a poor one for second flush teas and the effect of phosphoric acid in improving the quality and flavour of such teas was not apparent in 1933, as it was in 1932, when good quality teas were made in June.

Although the evidence obtained from this experiment is not perfectly clear, there are indications that,

(1) Phosphoric acid improved quality.

(2) Potash has a slight effect in the other direction.

In 1934 two experiments designed on the Latin square system were carried out, one in the second flush period and another during the rains period.

(1) *The effect of varying quantities of phosphoric acid with and without a constant quantity of potash.*

The leaf for the experiment was obtained from part of the Tingamira 9-acre block which is devoted to experiment on the effect of varying combinations of potash and phosphate manures on the yield of tea. The experiment in the field includes 16 plot-sets of 8 plots each.

Leaf from eight of the plot-sets was manufactured weekly on eight successive occasions during June and July. The manure mixtures applied to these eight series were such as to supply 40 lbs. nitrogen per acre (as sulphate of ammonia), together with quantities of superphosphate to supply phosphoric acid varying from 0 to 60 lbs. per acre, both in the absence of potash and with sulphate of potash to supply 30 lbs. potash per acre (see table below).

PLOT-SET.	Manure to supply lbs. per acre.		
	N.	P.	K.
2	40	0	0
5	40	15	0
9	40	30	0
13	40	60	0
3	40	0	30
7	40	15	30
11	40	30	30
15	40	60	30

The order of manufacture and the choice of roller was randomised for each set of four samples, those however from plots getting no potash being always manufactured before the four sets from plots to which potash had been applied. Thus the experiment is really resolved into two separate experiments, viz (i) varying phosphoric acid, no potash, and (2) varying phosphoric acid with 30 lbs. potash.

The two experiments were each arranged on a double Latin square plan so that each sample occupied during the eight occasions, every position in order of manufacture four times (twice in June and twice in July), and was rolled an equal number of times in each roller (twice each month).

The teas were sent to 4 tasters in India from whom complete valuations were obtained, and to three London tasters, from whom only 7 sets of valuations were obtained, those of the first manufacture being the missing ones. The tables below give the average valuations for Calcutta and London, for each set of teas, and for each taster individually.

TABLE XV.

Average valuations of 4 Calcutta Tasters in annas and pies.

Manuring lbs. per acre.	Date of Manufacture.								Average.
	June.				July.				
N. P. K.	5th	12th	19th	26th	3rd	10th	17th	24th	
40 0 0	11-2·1	11- 6·7	10-10·7	12- 5·1	11-2·6	12- 0·2	11- 0·6	11- 9·2	11-6·2
40 15 0	11-3·0	11- 6·0	11- 7·0	12- 3·0	11-3·0	12- 0·5	10-10·5	11- 9·5	11-6·9
40 30 0	11-2·5	11- 5·0	11-10·0	12- 0·0	11-8·0	11-11·5	11- 1·6	11-11·5	11-7·8
40 60 0	11-4·5	11- 6·0	11- 5·5	11-11·5	11-5·5	12- 1·0	11- 0·5	11- 5·0	11 6·4
40 0 30	11-7·5	11-11·0	11- 1·0	12- 5·0	11-3·5	11- 9·0	10- 9·5	12- 5·0	11-7·9
40 15 30	11-0·5	11-11·0	11- 1·5	12- 7·0	11-1·5	12- 3·5	11- 1·0	11- 5·0	11-6·9
40 30 30	11-7·0	11- 8·0	11- 9·5	11-11·5	11-6·5	12- 1·5	11- 4·5	11- 4·5	11-8·1
40 60 30	11-4·5	11- 8·0	11- 4·0	11-10·5	11-5·0	11- 4·0	11- 1·5	11- 4·0	11-5·2

The difference in the final average between the best and worst teas is only 1·6 pies for the "no potash" teas, and 2·9 pies for "potash" teas. These differences are a long way from being significant. There are indications that a moderate dose of phosphoric acid, without potash, has improved quality slightly. There is also a tendency for the heavy dose of phosphoric acid, to give a poorer tea than a moderate dose of phosphoric acid, whether potash is also present or not.

The results of these tasters taken individually also indicate no significant differences. Their averages are given below.

TABLE XVI.

Individual valuations of 4 Calcutta tasters in annas and pies.

lbs. per acre manure. N.	P.	K.	TASTERS. A	B	C	D	Average
40	0	0	11-10·9	11-10·2	10-10·0	11-5·6	11-6·2
40	15	0	12- 1·9	11-11·1	10- 9·0	11-5·6	11-6·9
40	30	0	12- 4·5	11-11·2	10- 9·8	11-5·6	11-7·8
40	60	0	12- 0·0	12- 0·4	10- 9·9	11-3·3	11-6·4
Average		...	12- 1·3	11-11·2	10- 9·7	11-5·0	11-6·8
40	0	30	12- 6·7	11-10·5	10-10·5	11-4·1	11-7·9
40	15	30	12- 0·0	12- 2·2	10-10·2	11-3·4	11-6·9
40	30	30	12- 7·1	12- 0·0	10-10·9	11-2·6	11-8·1
40	60	30	12- 0·7	11- 9·4	10-10·9	11-0·0	11-5·2
Average		...	12- 3·6	11-11·5	10-10·6	11-2·5	11-7·1

There are no significant differences in any of the sets of valuations for individual tasters.

As regards the opinion of the London brokers on these teas, complete valuations were received from only one taster. The first set of teas sent to tasters J and K suffered damage in the post, and their average figures therefore are based on only 7 out of the 8 sets of teas. This is particularly unfortunate, as the one taster who did give complete valuations, makes significant differences. The other two tasters might also have found significant differences had they been able to value all the sets of teas.

TABLE XVII.

Individual valuations of 8 London tasters in shillings and pence.

Manuring lbs. per acre.			Tasters.			Average.
N.	P.	K.	H	J	K	
40	0	0	1-3·2	1-1·2	1-2·1	1-2·2
40	15	0	1-3·6	1-1·4	1-1·8	1-2·3
40	30	0	1-3·2	1-1·9	1-1·9	1-2·3
40	60	0	1-3·8	1-1·7	1-2·1	1-2·5
Average ...			1-3·4	1-1·5	1-2·0	1-2·3
40	0	30	1-3·0	1-1·5	1-1·8	1-2·1
40	15	30	1-2·5	1-1·0	1-2·1	1-1·9
40	30	30	1-2·6	1-1·1	1-1·7	1-1·8
40	60	30	1-2·4	1-0·7	1-1·5	1-1·5
Average ...			1-2·6	1-1·1	1-1·8	1-1·8

There are no significant differences in the above valuations except in the case of Taster H, for the teas manured with varying quantities of phosphoric acid with no potash. His significant difference in this case is 0·38*d.* and he finds a significant difference in favour of the teas from the manuring with 40 lbs. nitrogen and 60 lbs. phosphoric acid, as compared with the teas from 40 lbs. nitrogen and either no phosphoric acid or 30 lbs. phosphoric acid.

Only 7 out of the 8 sets of samples were valued by tasters J and K and on these 7 sets, averages for which are given alone, they find no significant differences between averages of valuations for the various combinations of potash and phosphoric acid. The average valuations for all the three tasters indicate that the 8 different forms of manuring have on the whole produced teas as nearly alike as makes no matter. The maximum difference for

"no potash" teas is $\frac{1}{3}d$. and for the "potash" teas $\frac{3}{5}d$. These differences are well within the margin of error.

(2) *Varying quantities of potash with and without phosphoric acid.*

This experiment occupied the period from the beginning of August to the middle of September. Leaf from the following series of plots of the Tingamira experiment was manufactured on eight occasions.

Series.	Manuring lbs. per acre. Nitrogen.	Phosphoric acid.	Potash.
1	0	0	0
2	40	0	0
3	40	0	30
4	40	0	60
9	40	30	0
10	40	30	15
11	40	30	30
12	40	30	60

It was possible to obtain complete valuations from only two tasters in India; full sets of valuations were obtained from 4 tasters in London. The average valuations for all 6 tasters are given below.

TABLE XVIII.

Manuring lbs. per acre. N.	P.	K.	India annas per lb. A	C	Average India.	London. pence per lb. H	K	J	L	Average London.
0	0	0	10- 2·00	9- 8·12	9-11·06	14·59	12·69	13·34	11·91	13·13
40	0	0	10- 0·25	9- 7·62	9- 9·93	14·81	12·56	13·31	11·81	13·12
40	0	30	9-10·75	9- 8·25	9- 9·50	14·56	13·06	12·97	11·87	13·11
40	0	60	10- 0·25	9- 7·37	9- 9·81	14·06	12·75	12·97	11·47	12·81
40	30	0	10- 1·50	9- 8·00	9-10·75	14·50	13·09	13·38	12·56	13·38
40	30	15	10- 1·12	9- 7·87	9-10·50	14·72	13·44	12·84	11·60	13·15
40	30	30	10- 0·50	9- 8·19	9-10·35	14·72	12·87	13·00	12·00	13·15
40	30	60	10- 1·62	9- 7·62	9-10·62	14·09	12·59	13·00	11·37	12·76
Average.			10- 0·75	9- 7·88	9-10·32	14·51	12·88	13·10	11·82	13·06

Neither of the tasters in India nor tasters H, J nor K in London make any significant differences due to manurial treatment. The combined averages of the tasters A and C also do not show significant differences.

Taster L does give significant results. The significant difference required is 0·64*d*. which makes the teas manured with 40 lbs. nitrogen, 30 lbs. phosphoric acid and no potash significantly better than any except the teas manured with 40 lbs. nitrogen and 30 lbs. each of phosphoric acid and potash. The combined results of all four London tasters show significant differences. The significant difference required is 0·35*d*. Referring to the average valuations for the London tasters, the following manurial treatments give almost identical valuations :—

	Nitrogen.	Phosphoric acid.	Potash.
(*a*)	0	0	0
(*b*)	40	0	0
(*c*)	40	0	60
(*f*)	40	30	15
(*g*)	40	30	30

It is interesting that the unmanured samples are not preferred, although the actual yield given by the unmanured plots is only about two-thirds that of manured plots. Both samples with heavy doses of potash (60 lbs. per acre), get valuations either significantly worse than the rest, or very close to significance.

As in the 1933 experiments, the effect of phosphoric acid without potash is not on a 20 to 1 level of significance, but again the difference in favour of phosphoric acid is suggestive.

All four tasters place the heavy potash teas last and this at any rate seems definite, and again agrees with the 1933 results.

Summary of Results of Manuring Experiments.

1. There is definite evidence that very large applications (as for example quantities supplying 120 lbs. nitrogen per acre) of

inorganic manures reduce the quality of second flush teas. There is no definite indication that loss of quality results from the application of inorganic manures providing up to 40 lbs. nitrogen per acre, a quantity which has given *twice the crop* of *second flush tea*, as was obtained from unmanured plots.

2. No evidence has been obtained that organic manures have any different effect on quality of tea as compared with inorganic manures. Tea made from plots manured with sulphate of ammonia or cyanamide has, as often as not, been preferred to that made from plots getting the same equivalent quantity of manure in various organic forms.

3. From a number of experiments on the effect of potash and phosphoric acid on quality, in no case have results of a really definite nature resulted. Indications have however, in each case, been obtained, that phosphoric acid tends to improve quality, while potash has a slight effect in the opposite direction.

II. Effect of different styles of plucking.

Many different systems of plucking are, or have been, practised and it is by no means certain that any two systems will result in teas of equal quality, even though the crop from both may not differ materially. Firstly there are variations of "fineness" of plucking, involving the number of leaves of which the average shoot plucked and manufactured, shall consist. In actual practice this consists of from one leaf (in a very few instances) to 4 or (again in rare cases,) 5 open leaves. On some good quality gardens, in Assam more especially, the normal plucking consists of large "one leaf and a bud" shoots, and all "two and a bud" shoots which are "ready" after 5, 6 or 7 days from the previous plucking round. Rarely on these gardens do shoots with three open leaves find their way into a basket. In a more common form of plucking, specially on gardens with an average of less than about 1½ pluckers per acre, the plucking consists of shoots with two and three leaves. There may be enough labour to get round the garden in 7 days, but it may be impracticable, either for reasons of economy or for lack of that extra necessary labour, to keep rigidly to a "2 and a bud" standard, with the consequent breaking back of long shoots to the

plucking level. The result is that everything "ready" in 7 days is plucked and manufactured, except shoots with only one open leaf. This style of plucking is referred to subsequently as "Coarse" plucking. On very poorly laboured gardens, where the normal round of plucking is seldom less than 9 or 10 days, practically everything which is "ready" after this interval from the last plucking, is taken for manufacture, and an analysis of the average leaf basket would show a majority of shoots with three leaves; in addition double *banjhi* shoots, shoots of two leaves and shoots of four leaves would be present in proportion varying according to seasonal conditions. In order to obtain information on the relative quality of teas made from the various degrees of fineness of plucking, five standards of fineness have been employed in our experiments.

These are :—

1. Superfine plucking, consisting of all shoots with one or two open leaves.
2. Fine plucking, consisting of shoots with one large leaf, all "ready" shoots with two leaves, and single soft *banjhis*.
3. Medium plucking, consisting of nothing but shoots with two open leaves.
4. Coarse plucking, in which every shoot which is ready in 7 days, except those with only one leaf, is plucked.
5. Very coarse plucking, in which no shoots with less than three leaves are regarded as ready, and are plucked for manufacture.

Another debated point in connection with plucking is the effect on quality of the inclusion or non-inclusion of the *banjhi* shoot. This type of shoot is the result of temporary cessation of active growth of a shoot. The uppermost leaf having opened, grows slowly and "hardens up" without another leaf taking its place. It becomes in appearance and texture, though not necessarily in size, like a third or fourth leaf on a normally growing shoot. Does this leaf give the coarse liquor character which a normal fourth leaf does, or does it impart quality or even flavour

to the liquor? In the 1934 plucking experiment double *banjhi* shoots were plucked and manufactured separately off certain plots, and the resulting teas were compared with those from other types of shoot.

Another factor in connection with plucking and quality about which little definite information is available, is that of closeness of plucking, that is, the closeness which the plucking level is maintained throughout the season, to the original tipping level. A shoot breaking from the axil of a leaf below the tipping level, produces a tiny *janam* leaf, which as often as not falls off leaving merely a scar on the stem, then a non-serrated or only partially serrated leaf is formed, and is usually blunted or rounded at the top. After this the normal pointed and serrated leaves are formed. It is common practice to pluck leaving on the bush at any rate the *janam*, and often the unserrated leaf. Thus the plucking point of a shoot originating from just below the tipping level may be higher than the original tipping level. The result is that as the season progresses the actual plucking surface tends to get higher and higher and by the end of the season, even under conditions of strict supervision, is 3 or more inches higher than the original tipping level. When, as is the practice on some gardens, no breaking back of long shoots is done, or plucking is to the unserrated leaf, or even a leaf above this, the plucking level may rise a foot by the end of the season. The effect of these varying degrees of closeness of plucking on quality has received attention in the plucking experiments. The relative effects on quality; of three degrees of closeness of plucking were investigated.

1. Level of the plucking surface maintained by breaking back all shoots to the tipping level. This frequently involved breaking off the stalk below the *janam*.

2. All shoots broken back to the *janam*, but not harder than this. The plucking level rose about 3 inches from the tipping level by the end of the season.

3. No breaking back of shoots was done at all. An uneven plucking surface resulted, and by the end of the season many of the shoots were 8" or more above the original tipping level.

In 1934, the plucking experiment was carried out during the rains period (August and September), and in 1935, during the second flush period (June and July). For both experiments the same block of tea was used. It is of a dark leaf variety, planted in 1928 and giving about 8 maunds per acre with normally fine plucking as, for example that marked Fine 2.

(1) *The 1934 plucking experiment (Rains period).*

The following table gives details regarding the various styles of plucking, together with yields during the two months in 1934 in which manufacture was done :—

TABLE XIX.

Description of plucking.	Plucking instructions.	How broken back.	Yields for August and September, mds. tea per acre.		
			Growing shoots.	Banjhi shoots.	TOTAL.
1. Superfine ...	All shoots of one leaf and two leaves to be plucked (double banjhis plucked and weighed separately and not included).	To janam.	2·26	0·43	2·69
2. Fine 1 ...	Very large shoots of one leaf and a bud and all shoots of two leaves and a bud and all single banjhis plucked.	To original plucking level.	2·63	...	2·63
3. Fine 2 ...	As for Fine 1	To janam.	2·63	...	2·63
4. Fine 3 ...	As for Fine 1	Not broken back at all.	2·62	...	2·62
5. Medium ...	Shoots of two leaves plucked (double banjhis plucked and weighed separately).	To janam.	2·35	0·67	3·22
6. Coarse ...	All shoots of two or more leaves and all banjhis plucked.	Not necessary.	3·83	...	3·83
7. Very Coarse ...	All shoots of three leaves plucked (double banjhis plucked and weighed separately).	Not necessary.	3·76	1·02	4·78
8. Double banjhis.	The double banjhis of superfine, medium, and very coarse plucking were combined.	......	...	...	...

On every occasion of manufacture, an analysis of the percentage by weight and by numbers, of one and bud, two and bud, three or more leaves and bud, single and double *banjhis* in each of the leaf samples for manufacture, was made. From these figures the average weights of shoots of varying degree of fineness, was calculated.

In sorting, two grades were made, *viz*. a finer grade labelled B. P. consisting of 70-80% of the total bulk, and a coarse grade labelled Souchong, consisting of 15-25%. The remainder was a mixture of dust and small fannings and amounted to about 6%. Reports and valuations were obtained on the B. P. and the Souchong.

From the table below which gives the average results of the leaf counts and weights obtained on each of the eight samples, it can be seen that the plucking orders were reasonably well carried out. The superfine plucking consists almost entirely of shoots of one or two leaves and a bud. Counting erred on the strict side. Shoots with two fully opened leaves and one just uncurled from the bud were counted as three and a bud. Thus in many cases shoots counted as three and a bud, were possibly only two and a bud at the time they were plucked. Where there was doubt as to a shoot being *banjhi* or not, it was regarded as being *banjhi*.

The table of average weight of shoots is interesting. The superfine plucking gives smaller shoots of every type than do the freer styles of plucking.

Two and bud shoots from the very coarse plucking, and three and bud shoots from either coarse or very coarse plucking, are larger than those of the finer styles.

The double *banjhis* from coarse plucking are bigger than those from the finer pluckings.

There is no appreciable difference between the sizes of any of the shoots from the "fine" or "medium" pluckings.

TABLE XX.

Type of shoot.	1 Superfine.	2 Fine 1.	3 Fine 2.	4 Fine 3.	5 Medium.	6 Coarse.	7 Very coarse.	8 Double banjhi.	
A. Average percentage weight of shoots of different kinds in large samples.									
One and bud ...	18·2	8·2	6·5	5·7	2·5	1·1	0·1		...
Two and a bud ...	79·2	78·9	83·7	84·6	88·0	47·3	5·0		...
Three and a bud ...	1·7	5·2	3·6	3·1	6·0	39·8	93·2		...
Single banjhi ...	0·2	3·1	2·5	3·9	0·5	0·4	...		...
Double banjhi ...	0·7	4·6	3·7	2·7	2·0	11·4	1·7	soft	23·7
								hard	76·3
B. Average percentage numbers of shoots of different kinds found in large samples.									
One and bud ...	28·7	12·0	10·1	7·8	4·3	2·5	0·7		...
Two and bud ...	68·6	73·9	76·0	80·0	87·8	55·6	6·7		...
Three and bud ...	1·2	4·1	2·8	2·6	4·4	28·8	91·0		...
Single banjhi ...	0·5	4·9	5·9	6·0	0·9	0·6	...		...
Double banjhi ...	1·0	5·0	5·2	3·6	2·6	12·5	1·8	soft	26·2
								hard	73·8
C. Average weight of one shoot in grams.									
One and bud ...	0·16	0·19	0·21	0·21	0·20	0·19	0·18		...
Two and bud ...	0·32	0·33	0·37	0·37	0·37	0·37	0·57		...
Three ,, ...	0·40	0·42	0·42	0·48	0·48	0·60	0·81		...
Single banjhi ...	0·09	0·14	0·15	0·16	0·21	0·22	...		...
Double banjhi ...	0·17	0·24	0·23	0·24	0·27	0·42	0·68	soft	0·37
								hard	0·47
Average weight of shoots plucked.	0·24	0·28	0·32	0·33	0·34	0·40	0·77		0·45

Table XXI.

Calcutta valuations on B. P. grade.

Weekly averages of three tasters in annas and pies.

Series No. of plucking.	Dates of manufacture.								Average.
	August.				September.				
	10th	17th	24th	31st	7th	14th	21st	28th	
1	10- 4·0	10- 7·7	9- 9·0	9-11·0	9- 5·0	9- 9·3	9- 4·0	9- 8·3	9-10·4
2	10- 4·0	10- 2·0	9- 6·7	9- 7·3	9 0·0	9- 6·0	9- 9·3	9- 9·3	9- 8·7
3	10- 6·3	10- 6·0	9- 5·3	9- 3·7	9- 7·0	9- 7·7	9- 5·0	9- 8·7	9- 9·2
4	10- 5·7	9-11·0	9- 5·0	9-10·7	9- 5·7	9- 2·7	9- 8·0	9- 5·3	9- 8·2
5	10- 6·7	9-11·3	9- 6·3	9- 6·0	8-11·7	9- 6·0	9- 6·7	9- 4·0	9- 7·3
6	9-10·7	9- 7·3	8-11·0	8-10·0	9- 2·7	8-11·7	9- 1·3	9- 4·0	9- 2·8
7	9- 5·0	9- 7·0	8- 5·0	8- 5·7	8- 4·3	8- 8·7	8- 8·0	8-10·0	8- 9·7
8	9- 8·7	9- 6·0	8- 6·7	8- 6·0	8- 2·7	8- 7·0	9- 1·3	8- 6·3	8- 9·3
Average.	10- 1·9	9-11·8	9- 2·4	9- 3·0	9- 0·4	9- 2·9	9- 4·0	9 4·0	9- 5·3

The significant difference for the final averages is 2·59 pies.

There is no significant difference between the superfine and three fine forms of plucking. The superfine plucking alone gives significantly better teas than the medium plucking. All these five forms of plucking give significantly preferable teas to the coarse plucking, and this in turn gives significantly preferable teas to those from very coarse or *banjhi* plucking, which latter forms have produced teas of almost identical valuations.

The averages for individual *tasters* are next considered.

TABLE XXII.

Individual valuations of three Calcutta tasters.

Valuation in annas and pies.

Series No. of plucking.	A	C	E	Average.
1	10– 1·7	9– 2·0	10– 3·4	9–10·4
2	9– 9·4	9– 1·6	10– 3·0	9– 8·7
3	9–11·7	9– 1·1	10– 2·7	9– 9·2
4	10– 1·5	8–11·5	9–11·7	9– 8·2
5	9–10·4	9– 0·1	9–11·5	9– 7·3
6	9– 5·2	8–10·6	9– 4·6	9– 2·8
7	9– 0·4	8– 6·6	8–10·1	8– 9·7
8	9– 0·7	8– 8·1	8– 8·6	9– 9·8
Average ...	9– 8·1	8–11·1	9– 8·4	9– 5·3
Significant difference in pies.	0– 2·8	0– 2·7	0– 6·9	0– 2·6

All three tasters in India agree in making the teas made from the five styles of finer plucking significantly better than those made from the three coarser pluckings. They are also in agreement in preferring the teas made from coarse plucking to those made from the "three leaves and bud" plucking and the "double *banjhi*" leaf.

Among the finer plucked samples, agreement between the three tasters is not so good. Taster A puts the superfine plucking and the "not broken back" plucking significantly better than the other two styles of fairly fine plucking and the medium plucking.

Taster C. significantly prefers the superfine plucking to the medium and "not broken back" styles, but not to the two other styles of finer plucking, *i.e.*, "broken back to *janam*" and "broken back to tipping level".

Taster E valuing between wider limits than the others has a correspondingly large standard error and makes actually no significant difference between any of the five finer pluckings.

TABLE XXIII.

London valuations on B. P. grade.

Weekly averages of 4 tasters in pence.

Series No. of plucking.	Dates of manufacture.								Average.
	August.				September.				
	10th	17th	24th	31st	7th	14th	21st	28th	
1	11·9	12·8	13·0	13·1	12·8	13·1	12·4	12·3	12·67
2	12·6	12·3	12·4	12·3	12·9	13·1	12·7	12·6	12·60
3	12·2	12·8	12·0	12·0	12·7	12·4	12·4	12·4	12·36
4	11·5	12·4	12·6	12·7	13·4	12·4	12·7	12·6	12·54
5	12·2	12·2	12·2	12·3	12·6	12·6	12·7	12·6	12·42
6	11·7	12·1	11·8	11·9	12·8	12·4	11·8	12·1	12·06
7	11·1	11·3	11·2	11·2	12·2	11·7	11·2	11·7	11·45
8	11·6	11·3	11·0	11·1	11·4	11·4	11·3	11·3	11·30
Average	11·8	12·1	12·0	12·1	12·6	12·4	12·1	12·4	12·18

The significant difference of the average of all eight manufactures is 0·25*d*.

The London tasters as a whole find no significant difference between the superfine plucking and the fine plucking which was either heavily broken back or not broken back at all. The medium plucking and fine plucking which was broken back to the *janam*, are just significantly poorer than the superfine plucking. All forms of coarse plucking are significantly poorer than the finer forms of plucking. The teas made from very coarse plucking and *banjhi* leaf, are poorer than the teas made from ordinary coarse plucking.

TABLE XXIV.

Individual valuations of 4 London tasters.

Valuations in pence.

Series No. of plucking.	TASTERS.				Average.
	H	J	K	L	
1	11·6	13·5	13·4	12·1	12·67
2	11·7	13·5	13·1	12·2	12·60
3	11·4	13·0	13·2	11·8	12·36
4	11·7	13·1	12·8	12·4	12·54
5	11·5	13·4	13·0	11·7	12·42
6	11·2	12·7	12·7	11·6	12·06
7	10·2	12·5	12·0	11·1	11·45
8	10·3	12·0	12·2	10·7	11·30
Average	11·2	13·0	12·8	11·7	12·18
Significant difference ...	0·4*d.*	0·6*d.*	0·4*d.*	0·5*d.*	0·25*d.*

None of the tasters, individually, places the coarse plucking significantly worse than all finer forms of plucking. They value the "coarse plucked" teas better in comparison with the finer forms of plucking, than do the Calcutta tasters. Three tasters H, K and L significantly prefer the "coarse plucked" teas to the "very coarse plucked" and "*banjhi* leaf" teas. Taster J does not however place the "very coarse plucked" tea significantly lower than the "coarse plucked" tea, while the difference in the case of taster L is only just significant.

In general, with the 1934 market showing comparatively little discrimination, the various forms of fine or medium plucking are not differentiated to any extent either in Calcutta or London;

while, taking into account the increased crop from coarse plucking, this latter would have given a larger nett return than finer plucking, so small is the relative difference in valuation. The difference in price between fine and "coarse" plucking would have been counterbalanced by the increased cost of plucking alone.

(2) *The 1935 Plucking Experiment (Second flush Period).*

In the 1935 experiment the *banjhi* leaf manufacture was omitted and manufacture of leaf from another series was substituted. In this series no *banjhi* shoots were plucked, but were left on the bush to come through and recommence normal growth; when they had made 2 leaves above the original *banjhi* leaf, they were plucked.

Slight modifications were also made in some of the other series. The table below gives full details of the eight styles of plucking employed in this experiment.

TABLE XXV.

No.	Term applied to the style of plucking.	Type of shoots plucked and manufactured.	Details of breaking back.
1	Superfine ...	All one and a bud and all 2 and a bud and all single banjhis.	Broken back to janam.
2	Fine: heavily broken back.	Large shoots of 1 and a bud, all 2 and a bud and all single banjhis.	Broken back to original tipping level.
3	Fine: broken to janam.	As for 2.	Broken back to janam.
4	Fine: not broken back.	As for 2.	Not broken back, *i.e.* long shoots left on the bush.
5	Fine: no banjhis plucked.	Large shoots of 1 and a bud, all 2 and a bud.	Broken back to janam banjhis left to come through.
6	Medium ...	Nothing but shoots of 2 and a bud and double banjhis.	Broken back to janam.
7	Coarse ...	Everything but one and a bud and single banjhis	No breaking back necessary.
8	Very coarse ...	Everything larger than two and a bud or single banjhis.	No breaking back necessary

The average valuations of 6 tasters for each of the 8 teas made on each of eight occasions, are given below, together with the final average :—

TABLE XXVI.

Average valuations of 6 Calcutta tasters in annas and pies.

Series number of styles of plucking.	Crop in mds. tea per acre to July 31st.	Dates of manufacture.								Average.
		May.	June.				July.			
		31st	7th	14th	21st	28th	5th	12th	19th	
1	2·24 mds.	11- 0·00	11-5·50	12-2·00	11- 1·50	11-0·67	10- 6·67	10- 5·00	10- 8·11	11- 0·69
2	2·34 „	11-11·00	11-5·50	11-5·50	10-11·33	11-1·00	10-10·50	9- 7·17	10- 5·50	10-11·69
3	2·29 „	11- 5·00	11-3·00	11-3·83	10- 9·00	11-1·00	10- 6·50	10- 0·50	10- 3·17	10-10·00
4	2·40 „	10-10·50	11-5·00	11-5·33	10-10·83	10-8·83	10- 2·83	9-10·50	10- 8·83	10- 9·34
5	2·34 „	11- 0·67	11-7·50	11-4·67	10- 3·50	11-0·33	10- 9·50	9- 8·50	10-10·83	10-10·19
6	2·52 „	11- 3·00	11-7·33	10-7·50	10- 9·00	10-4·50	10- 2·50	10- 3·50	10- 2·17	10- 7·94
7	3·10 „	10- 2·83	11-5·00	10-8·00	9- 8·00	9-6·00	9- 1·00	8- 9·00	9- 6·50	9-10·29
8	3·85 „	8-10·50	9-6·50	9-4·50	8- 9·00	8-5·00	8- 4·00	8- 2·50	8- 6·50	8- 9·05
Average.		10- 9·94	11-2·66	11-0·67	10- 4·77	10-4·92	10- 9·04	9- 7·38	10- 1·96	10- 5·648

The significant difference of the final average is 3·9 pies.

Superfine plucking and heavy breaking back give teas which are significantly preferred to the *medium* or the coarse forms of plucking.

There is no significant difference between the superfine, or any of the four finer forms of plucking. The two coarse pluckings give teas inferior to all others, the very coarse being inferior to the moderately coarse plucking.

It is of interest to compare the individual valuations of the 6 tasters, which are shown in the table below.

TABLE XXVII.

Average valuations in annas and pies.

Series No of style of plucking.	Taster					
	A	B	C	D	E	F
1	10-11·2	11- 1·2	11- 1·5	10- 3·4	10- 7·0	12- 3·7
2	10-11·6	11- 0·4	11- 1·7	10- 2·6	10- 9·0	11- 9·4
3	10- 6·9	11- 2·0	10- 9·7	9-11·2	10- 8·7	11- 9·4
4	10-10·4	11- 0·4	10- 5·6	9- 8·2	10-10·4	11- 9·0
5	10- 9·7	10- 9·0	10- 3·7	9- 5·6	10- 9·7	11-11·2
6	10- 6·0	10- 8·6	10- 8·2	9- 9·7	10- 5·2	11- 9·7
7	9- 5·6	9-10·9	9- 9·4	8- 7·5	10- 1·7	11- 2·6
8	8- 6·0	8- 9·0	8-10·5	7-10·5	9- 6·7	8-11·6
Average	10- 3·9	10- 6·7	10- 6·2	9- 5·9	10- 5·8	11- 5·3
Significant difference in pies.	0- 5·1	0-10·8	0- 4·6	0- 9·1	0- 5·3	0- 8·0

In regard to the major differences, *i.e.*, between the superfine, medium, coarse and very coarse plucking, five of the 6 tasters are in good agreement, in placing the medium teas about half an anna lower, the "coarse" about 1½ annas lower, and the "very coarse" about 2½ annas lower, than the superfine plucking. Taster E makes the differences considerably less in each case.

No taster places the superfine plucking significantly better than any of the four styles of fine pluckings, nor these consistently better than the medium plucking. C is the only taster to make any significant difference between any of the four styles of finer plucking. He significantly prefers the tea containing no *banjhi* leaf to the tea which is not broken back, and to that which is broken back to the *janam*.

The combined results of the three London Tasters are as shown in the following table.

TABLE XXVIII.

Averages of 3 London Tasters' valuations in pence.

Plucking.	Dates of Manufacture.								Average
	May	June				July			
	31st	7th	14th	21st	28th	5th	12th	19th	
Superfine ...	13·75	14·67	13·58	14·50	14·42	14·00	13·08	14·17	14·02
Fine 1 ...	13·42	14·25	13·29	14·33	14·00	13·58	13·12	13·46	13·68
„ 2 ...	14·00	14·50	13·12	14·42	13·00	13·06	12·58	13·00	13·46
„ 3 ...	13·29	14·25	12·92	14·17	13·17	13·08	13·04	13·21	13·39
„ 4 ...	12·83	13·42	13·25	13·92	13·17	13·58	12·92	13·75	13·35
Medium ...	13·83	13·58	13·25	13·58	13·42	13·42	12·71	13·17	13·37
Coarse ...	13·25	13·83	12·58	13·50	13·42	12·50	12·50	13·08	13·08
Very coarse ...	11·75	13·00	12·17	12·83	12·17	11·83	11·50	12·25	12·19
Average ...	13·25	13·93	13·02	13·90	13·33	13·12	12·67	13·25	13·32

The required significant difference is 0·23*d*. Thus the superfine plucking has given teas which are regarded by the London tasters as significantly better in quality than all others. Among the four forms of fine plucking, it appears that the harder the breaking back, the better the teas. The teas from the most severe form of breaking back are significantly better than those not broken back at all, while the teas from bushes broken back to the *janam* occupy a position in valuation half way between the two extremes. The tea marked "Fine 4" is from bushes which were broken back to the *janam* (as for Fine 2) but no *banjhis* were plucked, being left on the bush to come through. The non-inclusion of banjhi leaf certainly has not resulted in superior teas. Medium plucking, consisting of shoots of two leaves and a bud and double *banjhis*, has produced teas which the London tasters place significantly poorer than those from superfine plucking, and fine plucking heavily broken back. The medium plucked teas are not however significantly worse than the other three styles of fine plucking.

Coarse plucked teas are slightly but significantly worse than teas from finer styles of plucking. Very coarse plucking has made much poorer teas, but nevertheless valued surprisingly well in comparison.

The individual averages for the three London tasters who valued all 8 sets of teas are given below.

TABLE XXIX.

Individual valuations of 3 London Tasters in pence.

Plucking.	H	J	K	Average.
Superfine	14·50	13·94	13·63	14·02
Fine 1	13·81	13·27	13·64	13·68
Fine 2	14·12	13·05	13·22	13·46
Fine 3	13·97	12·78	13·42	13·39
Fine 4	13·90	12·72	13·37	13·35
Medium	13·81	12·89	13·28	13·37
Coarse	13·41	12·94	12·97	13·08
Very coarse	12·20	12·13	12·25	12·19
Average ...	13·71	12·96	13·25	13·32
Significant difference ...	0·30*d*.	0·45*d*.	0·34*d*.	0·23*d*.

Tasters H and J both prefer significantly the tea from superfine plucking to all others, but taster K places it significantly better than only the fine plucking broken back to the *janam* and the medium and coarse teas. The three tasters are unanimous in not placing the tea from medium plucking significantly worse than the teas from the four styles of fine plucking, except for taster K, who does make it significantly poorer than the tea from heavy breaking back; this latter incidentally, he values highest of all.

Summary of Plucking Experiments.

(1) In general, the finer the plucking, the higher the valuation of the made tea. Differences are however surprisingly small, in both the 1934 and 1935 experiments.

(2) The superfine plucking produces teas which are often referred to as having more quality, but rather less strength and thickness of liquor than the teas made from the less fine styles of plucking in which no small "one and bud" shoots are plucked.

(3) Liquors from coarse forms of plucking are often reported on as having a coarse character; they are generally less bright, and do not cream down so well as the finer plucked teas.

(4) There is a tendency on the part of nearly all the tasters to prefer the teas from the closer styles of plucking in comparison with teas made from shoots which have been allowed to "run away" from the original tipping level.

(5) *Banjhi* leaf plucked in the rains period is definitely of poor quality. There is of course a strong belief, probably well founded, that autumnal flavour is increased by inclusion of *banjhis* at the end of the season. This point needs experimental confirmation.

(6) In the second flush period no improvement in liquor has resulted from leaving *banjhis* on the bush to break through, instead of plucking them off in the usual manner.

III. Influence of variety on the quality of tea.

Leaf was manufactured on six occasions weekly from the end of September to the beginning of November from plots containing the following varieties of tea :—

Tingamira	...	...	...	Borbhetta.
Burma	..	...	...	
Indo-China	...	...	...	
Kharikatia	...	...	...	Tocklai.
Kalline	...	...	..	
China	...	...	..	

The following is a brief account of each variety and history of the treatment which each of the 6 plots has undergone since planting.

I. *Tingamira.*—This is a light leaf Assam variety, from an Upper Assam seed garden, originally planted with indigenous seed. The plots at Borbhetta were planted in 1921.

II. *Burma.*—This is a small and dark leafed variety, the seed of which was originally obtained from Crozier's Agency, Silchar. The area was planted in 1920 and is close to the Tingamira block.

III. *Indo-China.*—Seed was obtained from wild plants growing in the forests in French Indo-China. It is a little similar in appearance to China hybrid, but the leaf is bigger, thicker, and smoother, while the red colour in the young leaf, and axils of old leaves is very characteristic. The area at Borbhetta was planted in 1922, and is divided from the Tingamira block only by a narrow path.

The other three varieties from Tocklai are all in the same block and have always been treated identically.

IV. *Kharikatia.*—This is a light leafed Assam variety being Singlo "once removed". It was put out at Tocklai in 1914.

V. *Kalline.*—Seed was obtained from the Kalline seed garden in North Cachar, which was planted with selected plants from

Burma seed. Planting and treatment at Tocklai is identical with that of the Kharikatia area.

VI. *China.*—Seed was obtained from bushes on abandoned teelas in Cachar. The parent plants of these bushes are reputed to have been brought direct from China. Treatment has been the same as that of the Kalline and Kharikatia jats.

The teas made from these six varieties were sent to four tasters in India and 4 in London, and the valuations obtained are given below.

The combined results of the India tasters are as follows :—

TABLE XXX.

Valuations in annas and pies.

VARIETY.	TASTERS.			Average.	TASTER.	Average including taster E.
	A	C	F		E	
Tingamira ...	10-0·00	10- 0·83	9- 8·00	9-10·94	12- 4·00	10- 6·21
Kharikatia ...	9-6·83	9-11·00	9- 2·83	9- 6·89	10-10·5	9-10·79
Burma	9-4·00	9- 7·83	9- 2·17	9- 4·67	11- 7·67	9-11·42
Kalline	9-1·50	9- 7·67	9- 2·50	9- 3·89	10- 1·00	9- 6·17
Indo-China ...	8-7·50	9- 4·17	8-11·67	8-11·77	9- 1·33	9- 0·17
China	9-1·33	9- 4·83	9- 1·50	9- 2·56	9- 1·50	9- 2·29
Average ...	9-3·53	9- 8·05	9- 2·78	9- 4·79	10- 6·33	9- 8·17
Significant differences in pies	0-3·56	0- 4·20	0- 2·39	0- 2·22	0-11·40	0- 4·05

Tasters A, C and F are in quite good agreement and the average of their valuations has a significant difference of only 2·22 pies. They place Tingamira significantly the best, Kharikatia significantly second. Burma is valued better than Kalline but the difference is not significant. China is valued lower than Burma and Kalline, but not significantly. Indo-China is significantly poorer than any except the China variety.

Taster E is valuing on a much wider basis than any of the others, and somewhat naturally has a larger standard error. He places Tingamira first, but not significantly better than Burma, which is preferred significantly to the other dark leaf *jat* Kalline, and to the two China varieties. These latter are placed equal last, and are significantly worse than the four other varieties.

The Kharikatia variety is placed lower than Tingamira and Burma, but the difference is not significant.

Results of Taster E should be regarded as a "minority" report, firstly because of his unique preference for Burma *jat*—an opinion shared by no other taster, secondly because he was valuing from the blenders' point of view, and thirdly because of his very wide range of valuations, which if combined with the other more conservative tasters, would unduly weight the average.

TABLE XXXI.

London Tasters' Valuations in pence.

VARIETY.	TASTERS. H	J	K	L	Average.
Tingamira ...	14·92	13·82	15·67	13·29	14·43
Kharikatia ...	14·08	13·21	12·92	12·37	13·15
Burma	13·25	12·79	12·92	12·21	12·79
Kalline	13·42	12·54	13·17	11·92	12·76
Indo-China ...	12·50	12·08	12·17	11·29	12·01
China	13·50	12·54	12·83	11·58	12·62
Average	13·61	12·83	13·28	12·11	12·96
Significant difference ...	0·62	0·49	0·87	0·50	0·41

The agreement between these four tasters is good enough to reduce the standard error of the average considerably. The Tingamira variety gives a tea which is very significantly the best, and Kharikatia is significantly better than China or Indo-China. Burma and Kalline are not significantly better than China, but are significantly better than Indo-China. China is significantly better than Indo-China.

Summary of results of the variety experiment.

The opinions of the tasters both Calcutta and London, may be summarised briefly as follows :—

Tingamira and Kharikatia, light leaf jats, give strong coloury liquors with Assam character and bright infusions. The Tingamira is decidedly preferable in these respects, and in addition has much more tip in the dry tea. Both teas have a brownish colour when compared with dark leafed varieties. The Kharikatia variety gave more tippy teas than did the dark leaf or China varieties.

Burma and Kalline—Gave strong coloury liquors, without stand-out quality. Infusions fairly bright but greenish, and duller than the light leaf *jats*.

Burma is on the whole slightly preferred to Kalline, but except in the case of taster E, the difference is not significant. Both *jats* give very black tea, with a poor show of tip.

China.—A thin liquoring tea with an undesirable character often referred to as "weedy" or "grassy". One or two of the later samples showed distinct "Darjeeling" flavour but not enough to off-set the thinness of the liquor. In tip and appearance the China variety tea is rather better than the dark leaf *jats*, but inferior to the light leafed.

Indo-China gave a thin liquor with no quality. The samples of the last two manufactures had a touch of flavour, though this was referred to by two tasters as weedy or grassy. The dry tea had an almost blue-black appearance and was always entirely lacking in tip.

APPENDIX.

THE STATISTICAL METHOD OF ANALYSIS OF VARIANCE.

When, as a result of repeating an experiment a certain number of times, average values are obtained for each of the treatments under investigation, these averages may differ by a large or small amount. If the differences are very small, common sense will tell one that the treatments have not produced any significant differences, especially if, as usually is the case, a comparison of the individual experiments shows that their results vary from each other. Take for example, valuations of two teas A and B which have under-gone different treatments.

		Valuations.					AVERAGE.
A.	...	10	10	11	9	10	10·0 annas.
B.	...	9	10	11½	9	9	9·7 ,,

The difference is only one-third of an anna for the average of 5 valuations. Inspection of these valuations show that A is better than B on two occasions, worse on one occasion, and equal to B on two occasions. The logical conclusion is that no case is made out for treatment A being better than B.

If however we have the following valuations :—

		Valuations.					AVERAGE.
A.	...	10	10	11	11	10	10·4 annas.
B.	...	9	9	10	11	9	9·6 ,,

A is better than B *four times out of five*, and equal once, so that a reasonable conclusion is that A is really a better tea than B.

Between these extremes however, there are cases where it is impossible to judge whether a difference is really significant. The statistical method known as the Analysis of Variance, which is employed by all modern scientific workers, determines the chances in favour of differences between averages being really significant.

It is obvious that exact mathematical expressions cannot be applied to tasting reports which merely give a taster's opinions on colour, quality, strength etc. of liquors, nor can the analysis of variance be legitimately applied to results which consist merely in placing teas in order of merit, since this method gives no measure of the magnitude of differences between the teas. Valuations therefore have to be obtained, and in order to mark small differences between teas which the market would normally value the same, brokers have in general valued to the nearest $\frac{1}{12}$th of an anna (Calcutta) or $\frac{1}{8}d$. (London).

A typical arrangement of an experiment such as those already described is shown in Table I.

Taking the manufacture done on the 10th August, the first pair of teas started their roll at 4 A.M.,—the "coarse" plucking in the roller labelled "East", and the "Fine I" plucking in the "West" roller. These finished their rolling together at 5-30 A.M. and were then taken to the fermenting floor, and the rollers charged with the next pair of samples. These in turn gave place to the third pairs at 7-0 A.M., and finally at 8-30 A.M. the fourth pair were rolled. All samples had the same fermentation time and were thus fired in pairs, at intervals of $1\frac{1}{2}$ hours. On succeeding days' manufactures, the order in which the samples were rolled was varied, so that by the end of eight manufactures each tea had been rolled first, second, third and fourth, on two occasions each, (once in the East and once in the West roller). The valuations in table II correspond to the treatment given in Table I.

TABLE I.

Latin Square Arrangement for Plucking Experiments.

Order of rolling.	Roller.	DATE OF MANUFACTURE.							
		10th Aug.	17th Aug.	24th Aug.	31st Aug.	7th Sept.	14th Sept.	21st Sept.	28th Sept.
1st ...	East	coarse	Fine 3	medium	superfine	Fine 1	banjhi	very coarse	Fine 2
	West	Fine 1	coarse	superfine	banjhi	Fine 2	medium	Fine 3	very coarse
2nd	East	medium	superfine	Fine 2	Fine 3	coarse	very coarse	banjhi	Fine 1
	West	banjhi	Fine 2	very coarse	medium	Fine 3	superfine	Fine 1	coarse
3rd	East	Fine 2	banjhi	Fine 3	coarse	very coarse	Fine 1	medium	superfine
	West	Fine 3	very coarse	banjhi	Fine 1	superfine	Fine 2	coarse	medium
4th	East	very coarse	medium	Fine 1	Fine 2	banjhi	coarse	superfine	Fine 3
	West	superfine	Fine 1	coarse	very coarse	medium	Fine 3	Fine 2	banjhi

Table II.

Valuations in pence corresponding to samples as in Table I.

Order of manufacture.	Roller.	Date of manufacture.								Average valuation.
		10-8	17-8	24-8	31-8	7-9	14-9	21-9	28-9	
1	E	10¾	11¾	11½	12½	11½	10¾	11	12	11·47 d.
	W	12¼	11½	12½	10¾	13	12¼	12¾	11¼	12·03 „
2	E	11¾	12	10¾	12½	12½	11½	10½	12½	11·75 „
	W	10½	12½	10½	12	13½	13¼	12¾	11¾	12·09 „
3	E	12	10¼	12	11½	13¼	13½	12¼	11¾	12·06 „
	W	11	10¼	10¼	11¼	11¾	11¾	11¼	11½	11·12 „
4	E	10½	10¾	12¼	11¼	11¼	12½	11¾	12¾	11·66 „
	W	11¼	11¼	11¼	10¾	12	13	11¼	11¼	11·50 „
Averages	...	11·25	11·28	11·37	11·56	12·34	12·31	11·72	11·84	11·71 d.

The average of all 64 valuations is 11·71*d*. To simplify the arithmetic, the difference between each valuation and a rough average (called the "crude mean") of 11¾*d*. is used for working out the results. The table below is therefore the same as table II except that valuations are written as differences in farthings from 11¾*d*. and the figures in the last column and bottom row are totals instead of averages.

Table III.

(Deviations from crude mean 11¾d. in farthings).

Order of manufacture.	Roller.	Dates of manufacture.								Totals.
		10-8	17-8	24-8	31-8	7-9	14-9	21-9	28-9	
1	E	-4	0	-1	3	-1	-4	-3	1	-9
	W	2	-1	3	-4	5	2	4	-2	9
2	E	0	1	-4	3	3	-1	-5	3	0
	W	-5	3	-5	1	7	6	4	0	11
3	E	1	-6	1	-1	6	7	2	0	10
	W	-3	-6	-6	-2	0	0	-2	-1	-20
4	E	-5	-4	2	-2	-2	3	1	4	-3
	W	-2	-2	-2	-4	1	5	-2	-2	-8
Total	...	-16	-15	-12	-6	19	18	-1	3	-10

The correction for taking the crude mean of 11·75*d.* instead of the exact mean of 11·71*d.* is given by the square of the grand total (-10) divided by the total number of samples *i.e.* $\frac{10\times10}{64} = 1{\cdot}56$. This correction must be deducted from all variances.

The total variance is given by the sum of the squares of *all* the individual differences from the crude mean, less the correction.

Total variance $= 722 - 1{\cdot}56 = 720{\cdot}44$.

Treatment variance.—By reference to Table I and table III, the total deviation from the crude mean can be obtained for each treatment; *e.g.* for superfine plucking, the deviations are as follows:—

Date of manufacture.

10-8	17-8	24-8	31-8	7-9	14-9	21-9	28-9	Total
-2	1	3	3	0	6	1	0	12

Similarly for each of the other treatment, giving the following:—

TABLE IV.

TREATMENT TOTALS.

Style of plucking.	Deviations.	Square of deviations.
Superfine	12	144
Fine 1	31	169
Fine 2	2	4
Fine 3	21	441
Medium	0	0
Coarse	-4	16
Very coarse	-20	400
Banjhi	-34	1156
		2330

The treatment variance is given by the sum of the squares of the treatment deviations in the above table, divided by the number of repeats of each treatment (*i.e.* 8), and less the correction.

$$\text{Treatment variance} = \frac{2330}{8} - 1{\cdot}56 = 289{\cdot}69.$$

Order of manufacture variance.—The variance due to order of manufacture is obtained from the totals in the last column of Table III.

The deviations for each order of manufacture are—

——	Rolled at	Total deviations.	Squares.
1st pair ...	4-0 A.M.	0	0
2nd pair ...	5-35 A.M.	11	121
3rd pair ...	7-40 A.M.	-10	100
4th pair ...	8-45 A.M.	-11	121
			342

The variance due to order of manufacture

$$= \left(\frac{\text{sum of squares of deviations}}{\text{number of samples comprising each pair}}\right) \text{minus the correction.}$$

$$\text{Order of rolling variance} = \frac{342}{16} - 1{\cdot}56 = 19{\cdot}81$$

Roller action variance.—The variance due to the different action of the rollers is also obtained from Table III.

	Total deviations.	Squares.
East roller	-2	2
West roller	-8	64
		68

$$\text{Roller action variance} = \frac{68}{32} - 1{\cdot}56 = 0{\cdot}64$$

Date variance.—There is a difference in average valuations from week to week, depending partly on the relative intrinsic values of the eight sets of samples, and also on the state of the market from week to week. This variance is given by the sum of the squares of the "week to week" deviation totals, divided by the number of teas valued each week (8), less the correction.

$$\text{Thus date variance} = \frac{1356}{8} - 1{\cdot}50 = 167{\cdot}94$$

Interaction of order and rollers.—One more variance is obtainable, and is the variance due to the "interaction between the rollers and the order of manufacture". Reference to the last column of table III shows that in the case of the first pair of teas manufactured each week, those rolled in the East roller have a much better average valuations than those in the West roller. In the case of the second pair the difference is not so great, but in the same direction. In the case of the third pair there is a very much bigger difference in the *opposite* direction, while for the fourth pair there is a slight difference again in favour of the East roller. This varying effect of the roller action according to the relative time at which the rolling takes place, is measured by the variance due to interaction, (order x rollers).

First, the sums of squares of the figures in the last column of table III are obtained. This is divided by 8, and the correction 1·56 subtracted. This gives the total variance due to roller action, order of manufacture and interaction of the two. $\frac{856}{8} - 1·56 = 105·44$. From this, the order variance and the roller variance are subtracted.

Thus 105·44 − 19·81 − 0·64 = 84·99 (Interaction order X rollers). Our total variance concerned with effect of order and rolling is thus made up of three parts.

In the table below the results obtained are tabulated :- -

Analysis of Variance Table.

—		Variance.	Degrees of freedom.	Mean squares.
Treatment variance.		289·69	7	41·384
Date of manufacture variance.		167·94	7	23·991
Variance concerned with effect of roller action and order of manufacture.	Roller action	0·64	1	0·640
	Order of manufacture.	19·81	3	6·603
	Interaction of roller action and order of manufacture.	84·99	3	28·33
Residual variance.		157·37	42	3·747
TOTAL VARIANCE ...		720·44	63	...

The degrees of freedom are the number of comparisons possible, that is in each case, one less than the number of individuals concerned, *e.g.* as there are 64 samples, each can be compared with 63 others, hence the total number of degrees of freedom is 63. The treatment variance is that of 8 treatments, hence for treatment there are 7 degrees of freedom, and so on.

The mean square of the variance for any particular factor (*e.g.* date, treatment, roller action etc.) is the variance divided by the number of degrees of freedom, and is the true measure of the effect of the particular factor on the valuations of the teas.

We first wish to know whether a factor is really influencing the valuations or not. If it is, then its mean square must be greater than the mean square of the residual variance by a certain amount. This amount depends on two things.

(*a*) The number of degrees of freedom for the particular factor and for the residual variance.

(*b*) The level of significance required. It is usual in agricultural practice to accept odds of 20 to 1 in favour of difference between any two results, which is greater than the calculated significant difference, being really due to the treatment, and not to chance. From statistical tables, the ratio between the two mean squares of variance referred to above can be found, taking into account the degrees of freedom, and level of significance required. This process is known as "application of the Z test."

In the example we are concerned with, the mean squares for treatment and date variance must be about $2\frac{1}{4}$ times the residual mean square, for a 20 to 1 chance of significance. Actually both variances are much more than this and are therefore significant.

The order of rolling variance must be over $2\frac{3}{4}$ times, and the roller action variance 4 times the residual variance. As this is not the case neither of these variances is significant.

The square root of the mean square for residual variance gives the "standard error", which in this case is $\sqrt{3{\cdot}747} = 1{\cdot}936$. This

means, that, judged by the form shown during this experiment, any single tasting is liable to an error not exceeding 1·936 farthings.

A possibility of error of about $\frac{1}{2}d$. seems high on this market even on a single tasting: but it must be remembered that this estimate of error includes all sources of error not specifically allowed for in the analysis of variance, including sampling errors not only at Tocklai but in the selection of a weighment from the sample tin, and that although we can allow for the average difference between *e.g.* rolling at 4-0 A.M. compared with rolling at 8-45 A.M. we know that this difference in time of rolling cannot make the same difference in quality every day.

The standard error of a difference between any two tastings is $\sqrt{2} \times 1{\cdot}936$ or 2·73 farthings. Hence a comparison between two single tastings under these conditions has little significance. We have however to compare averages of a large number of tastings.

If the Z test is first passed, then the significant difference of the date or treatment totals is given by the expression.

$$t \times \sqrt{2} \times \sqrt{\text{mean square of residual variance} \times \text{No. of samples comprising the totals}}$$

where "t" depends on the degrees of freedom of residual variance and on the odds on the significance required.

For 42 degrees of freedom and odds of 20 to 1 on significance $t = 2{\cdot}020$.

Thus the Significant Difference $= 2{\cdot}020 \times \sqrt{2} \times \sqrt{3{\cdot}747 \times 8}$
$= 15{\cdot}64$.

Comparing the deviation totals of the various treatments (Table IV) any difference between any two of these totals which is greater than 15·64 indicates that the odds are at least 20 to 1 on the difference, whatever it is, being really due to the difference in treatment and not to chance.

The average valuations, in pence, of the different treatments, are obtained from the Table IV by dividing by 4 (to bring farthings to pence) and again dividing by eight (to get the average of the eight valuations of which the figures are totals) and adding the crude mean $11\frac{3}{4}d$.

The following average valuations for treatment are obtained :—

Plucking treatment.	Average valuations in pence per lb.
No. 1. Superfine ...	12·125*d.*
2. Fine 1 ...	12·156*d.*
3. Fine 2 ...	11·813*d.*
4. Fine 3 ...	12·407*d.*
5. Medium ..	11·750*d.*
6. Coarse ...	11·625*d.*
7. Very coarse ...	11·125*d.*
8. Banjhi ...	10·688*d.*

The significant difference for these averages in pence

$$= \frac{15{\cdot}64}{4\times 8} = {\cdot}490d.$$

The highest valuation is that of Fine 3,—12·407*d.* Any valuation of 11·917 or above must be considered to be equal to 12·407 within experimental error.

Plucking treatments 1, 2 and 4 must therefore be concluded to give equally good teas.

Fine 3 is significantly better than medium, or any of the coarse pluckings. All four fine pluckings are significantly better than the very coarse or banjhi pluckings.

In a similar way the average valuations for each date of manufacture are obtained and the significant difference is the same as that for treatment averages, there being the same number of treatments as there are repeats of the manufacture.

	August.				September.			
Date of manufacture.	10th	17th	24th	31st	7th	14th	21st	28th
Average valuation. (in pence)	11·250	11·28	11·375	11·563	12·344	12·313	11·7[illegible]	11·8[illegible]

The average valuations for order of rolling are :—

1st	11·750*d.*
2nd	11·922*d.*
3rd	11·594*d.*
4th	11·578*d.*

There is no significant difference between these averages, that is, the order of rolling has not affected valuations in this experiment.

The average valuations for the two rollers are :—

East roller ...	11·734*d.*
West roller ...	11·687*d.*

There is no significant difference between these averages, hence in these experiments the two rollers were giving teas of practically equal values.

In the experiments described previously, when two or more tasters have valued the teas, the analysis of variance is worked out for the averages of their valuations on each tea, otherwise the method is exactly as described above.

C. P. W.—1177—17-1-36—1,200.

TOCKLAI EXPERIMENTAL STATION.

BOTANICAL BRANCH

NOTES ON TUNG.

Calcutta:
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1936.

The following "Notes on Tung" represent a collection of miscellaneous documents taken from the Tocklai files, together with abstracts copied from scientific abstracting journals. As these documents appear to be of interest to those attempting to grow tung in Assam, it has been decided to issue them in their present form. Such knowledge as we have obtained at Tocklai relating to tung culture is too scanty to allow of any comprehensive treatment: most of our data requires confirmation and is of little value when removed from its original context, and for this reason no attempt has been made to unify the original material. Our thanks are due to the Imperial Agricultural Bureaux, whose abstracts we have freely copied, for making readily available the useful knowledge acquired by other workers in other countries. In Assam, Mr. Withers at Nolini is to be congratulated as the pioneer of tung culture; and from whose efforts most of our knowledge at Tocklai has arisen: in particular, Memo. No. 151/B. 36 was prepared in consultation with Mr. Withers.

Report No. 151/B.36.

19th June 1936.

1. General.—Several problems require immediate attention if there is to be any hope of making a success of tung growing. The problems are such as require the attention of an experienced experimenter. The full time attention of a qualified investigator would give results of commercial importance—by results of commercial importance I do not necessarily mean results which will make tung growing an unqualified success in Assam for it would obviously be of commercial importance to know that tung growing is a waste of time and money. The potentialities of tung growing are, however, so great that it is the duty of those who are concerned with the welfare of Assam to direct and assist in the solution of the immediate problems which beset the "industry"; and which if they are not now solved, are certain to involve individual concerns in monetary loss. The demand for tung oil greatly exceeds the supply and is likely to do so for some time: the properties of the oil are such that an increased supply of oil will almost certainly mean an increase in the number of uses for the oil: tung growing might easily form the adjunct to tea growing discussed by the Commission of Enquiry into the Tocklai Experimental Station (*cf.* para 14, p. 11): tung growing is, moreover, a potential village industry. These are possibilities which should be investigated by those concerned with the welfare of Assam and of the tea industry. These general aspects of tung growing are

really outside my province, which is to give advice in particular cases when called upon to do so. At the same time, it is evident that attempts to establish tung in this country lack direction and that the issues involved are not realised by those in whose power it lies to give the necessary direction: neither are the problems with which a few pioneer practical men are now grappling understood by those who could assist in their solution; I cannot resist, therefore, prefacing my notes with the foregoing remarks. It is up to others to state the case for the potentialities of tung growing—the evidence is not hard to find. The immediate problems of the practical man should be clear from the following notes. Here and there are suggestions for simple experiments; these are not by any means exhaustive, but are such as can be carried out by the practical man and will give valuable preliminary information: no experiment should be repeated less than three times, and many more times is desirable.

2. Die back. Aleurites Fordii.—*A. Fordii* is markedly affected by the type of soil. Under certain conditions the tree shows a considerable amount of "die-back" and this would appear to indicates that the soil is unsuitable for the growth of *A. Fordii*, at least, in the absence of greater cultural knowledge than we possess at present. At Borbhetta, *A. Montana* succeeds quite well under conditions which cause unsatisfactory growth of *A. Fordii.*

3. Root æration.—One of the major factors in the growth of *A. Fordii* seems to be root æration. The roots appear to require far more oxygen than those of *A. Montana*, and the tree appears to be susceptible to any diminution of the necessary oxygen supply. These are surmises based on field observations: the susceptibility of the plant to waterlogging and the necessity for good drainage has several times been pointed out. I have examined the roots of *A. Fordii* and find that lenticel development is marked, particularly so on trees showing "die-back": on some of the latter trees the lenticels might be described as hypertrophied. This excessive development of lenticular tissue suggests lack of oxygen[1] and I suggest that the bad effects of waterlogging are really due to oxygen shortage incident on the waterlogging. Good drainage may reduce or entirely do away with water-logging, but the soil will still be left in such a condition that æration is bad. I think that considerable attention must be given to the preparation of some soils before the trees are planted. Maybe it is not a commercial proposition to give the desirable treatment but in that case it is not a commercial proposition to grow the trees at all. On

[1] *Cf.* Journ. Agric. Res. XX(4): 253-265, 1920.
Amer. Journ. Bot. 17(8): 842-861, 1930.

land such as I saw, the soil should be thoroughly broken up for a diameter of six feet and a depth of at least 2'6" on the site for each tree; all jungle roots should be removed. The incorporation of large quantities of broken brick, pebbles, prunings, old thatch etc., with about 18" of the subsoil works wonders with such land in horticultural operations. I am told that this treatment simply draws more water towards the roots of the plant; possibly so, but this water is more likely to be oxygenated than on similar untreated land. I think that some experiments should certainly be undertaken along these lines, and would suggest that numbers of young trees of *A. Fordii* be planted on the "die back" area, some without any previous treatment of soil, some with previous kodallie treatment to varying depths, some with varying depths of river pebbles or broken brick incorporated in the sub soil, and again others raised on mounds (of large diameter) some of soil alone and some of soil plus pebbles.

4. Thatch grass and jungle.—Light jungle, and thatch grass in particular, between the trees, is probably harmful: the bad effects of sod on apple trees are well known. The roots of other plants around the tung trees will increase competition for the available soil oxygen and the presence of jungle is hardly likely to facilitate the diffusion of oxygen into the soil.

5. Nature of Growth.—Terminal growth of the tung tree is strong at first, but unless dormant buds on the "frame" come into growth the tree becomes undesirably leggy and will bear a very small crop of seed relative to its size. The amount by which the frame "fills up" varies considerably from tree to tree, as also does "vigour" and total size at a given time.

6. Starch in the roots.—Starch can easily be demonstrated in both the roots and shoots of *A. Fordii*. For a field demonstration the roots are more satisfactory. The roots of healthy trees contain more starch than those of unhealthy: this fact should not be regarded as a "test" as it simply states in other words what can easily be seen from other symptoms: in certain circumstances it might be useful, but great care should be taken to compare roots which are in exactly the same physiological condition as there is an inherent fluctuation between much starch and less starch in both healthy and unhealthy trees. Trees which are noticeably late in coming away (this includes "die back" trees) contain much starch as compared with similar trees which "come away" early.

7. Nitrogen.—The characters of trees bearing a high percentage of female flowers (*A. Fordii*) suggest a high nitrogen metabolism. Cutting back (*cf.* para 11) probably induces a similar type of growth. This suggests

that the application of nitrogenous manures might be beneficial, so that this should be borne in mind when applying manures.

8. Manuring—general aspects.—Manuring might be undertaken with the aim.

(1) Of improving the general health, and resistance to disease, of the tree.

(2) Of increasing the percentage of female flowers (*i.e.* altering the the sexuality of the trees).

(3) Of increasing the weight of the fruits.

(4) Of increasing the percentage of oil in the fruits.

It has been stated that Neem (*Azadirachta indica*) cake increases the percentage of oil in Castor Oil (*Ricinus communis*). Anything which increases the oil content of castor oil is likely to have the same effect on tung, so that this is a possibility to be explored. The evidence for the statement was not conclusive; the author of the paper[1] promised further experiments, but I have not been able to find any reference to these.

9. Effect of stock on scion.—*A. Montana*, in certain places, grows better than *A. Fordii*. If *A. Fordii* is budded on to *A. Montana* stocks growing in such places, then the resultant growth of the *A. Fordii* is still inferior, and typical of growth on its own root stock.

10. Sex differences: A. Fordii.—A previous report has dealt with the variations in sex. As it is these variations which primarily affect crop an early step in a scheme of experimental work should be to determine whether sex differences are inherent differences, or are due to soil; they are probably in a certain degree due to both, but it is very important to determine how far they are likely to be affected by external conditions. I would suggest—

(1) If it is possible to root cuttings, that numbers of pairs of "male" and "female" trees be taken and cuttings from the male be planted alongside the female and *vice-versa*.

(2) A similar interchange of buds be made, *i.e.*, again using pairs of trees, graft a "male" bud on to a "female" tree and *vice-versa*. this is open to the objection of interaction between bud and stock, but observation suggests that this is negligible (*cf.* para 9).

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[1] Sethi, R. L., Observations on the Castor Oil plant (*Ricinus communis Linn.*) in the United Provinces. Agriculture and Live Stock in India. I (3): 243-262. 1931.

(3) Large numbers of trees may be cut back so as to form stocks on each of which a pair of buds, one from a "male" and one from a "female" tree is grafted. Interaction between stock and scion will be the same for male as for female in this case.

11. Aleurites Montana.—*A. Montana* is dioecious, or almost entirely so *i.e.*, male and female flowers are generally borne on different trees. The sexuality shows slight signs of change, mainly in the production of female flowers on male trees: it is doubtful if these are more than transient metabolic disturbances. Young female trees are said to later turn into males and there is therefore the possibility of the reverse change taking place: it is probable that after a few years (say 5-6) the tree will come to a stable equilibrium when no more change need be expected. Similar considerations probably apply to *A. Fordii* so that bud wood should not be selected too soon. A male tree of *A. Montana* seems to be in a more stable condition than a female tree and more female trees seem to change towards the male condition than *vice-versa*—this is irrespective of the occasional production of female flowers on male trees. The wounding of a male tree of *A. Montana* appears to result in a localised production of female flowers (*cf.* old idea of cutting back a male papaya). Even in the absence of evident wounding the production of female flowers on male trees is always local. Evidence given to me indicates that the change from a young female tree to a male is complete. After a reasonable lapse of time I do not think that there is any chance of the reverse change occurring.

Although *A. Montana* trees are in a much more stable condition than *A. Fordii*, slight changes do occur and these suggest that manurial treatment, at least in the early stage, might be beneficial: with any change induced by manurial treatment there will, however, remain the problem as to what will happen when the treatment is discontinued.

A. Montana, being practically dioecious, is more likely to give higher yields per acre because a large number of purely female trees will be satisfactorily pollinated by one male tree.

12. Pollination.—The question of pollination requires investigation, especially in the case of *A. Montana*. In *A. Montana* the female trees open their flowers before the male trees: fruits are "set" on the female trees before the male trees open their flowers. In the case of female, or part female, branches on male trees I found "set" fruits along with unopened flower buds in the same inflorescence—all the unopened buds were males. The least that one can say is that a relatively scanty source of pollen suffices for a large number of female trees.

13. Morphological characteristics.—I cannot suggest any practical method of identifying male or female trees before they come into bearing.

14. The Tung "Industry."—This could be developed along one or more of three lines.

(*a*) As a cottage industry, the oil being extracted at a central plant prepared to buy seed from the villagers.

In considering tung as a cottage industry the experience of the lac industry would be valuable.

(*b*) As an adjunct to the tea industry. Tung may well meet the case of the adjunct referred to in para 14 (p. 11) of the Report of the Commission of Enquiry.

(*c*) As a self supporting industry, not connected with other concerns. In this case the variety would determine the type of soil and district where the industry would be established. Manurial treatment that would preclude success, for example, as a village industry might be immaterial to a large self supporting industry with adequate finance.

15. Oil of A. Montana.—The oil of *A. Montana* has been reported as less desirable than that of *A. Fordii* and does not seem likely to fetch such a high price as oil of the latter. Dissatisfaction with these reports has been expressed by certain parties: this is a matter which should be examined at once, as it is of the very greatest importance. If the least possibility of doubt as to market value remains, then sufficient undoubted *A. Montana* seed to provide a sample adequate for all the tests of the consumer, should be grown without delay. In the light of the evidence so obtained, those concerned with the growing of tung should then seriously consider whether to direct their efforts towards the production of one variety only, or whether to encourage the cultivation of both *A. Fordii* and *A. Montana* according to local circumstances. Considering the welfare of the industry as a whole it is very desirable that the greatest uniformity in the type of oil be maintained. This, however, can only be achieved by co-operative and centralised action. The sole cultivation of one variety is probably more desirable than the cultivation of two varieties, even if it means the universal adoption in Assam of a variety yielding oil of a lower market value.

The problem of *Montana* oil versus *Fordii* oil is at the moment *the* problem of tung growers and any other development seems futile until this is satisfactorily settled, and settled with the seal of approval of some recognised authority. If *A. Montana* is to oust *A. Fordii* in Assam than half the troubles of the tung grower will automatically disappear.

Report No. 158/B.36.

6th July 1936.

1. Variation of tung seedlings. (Hort. Absts. II(4): 393. 1932). "On two seedlings of known parentage the fruit characters were found to be closely identical with those of the parent. Plantings on a large scale are being made to get conclusive evidence on this point."

This would fit in with a self pollinated tree and would be just the opposite condition (and give just the opposite result) to that obtaining in a tea bush cf. para 12 in my previous memo. No. 151 and a para in memo. 4/B.32 both dealing with pollination of tung.

2. Success in other countries.—(from Hort. Absts. II(2): 179. 1932). In Ceylon repeated trials have shown that *A. Fordii* will not flourish though *A. Montana* appears to do well. The Malayan Agricultural Department advise that both species are suitable for cultivation on the plains, though trial plantings are still under observation in the hills at 5,000 ft. In New Zealand plants have been raised without difficulty and growth appears to be good. Five public companies with a total nominal capital of £780,000 have been formed to develop the cultivation of this product in the North Island. Experimental trials are in progress in all British countries in South and East Africa. *At present results are indefinite and not particularly encouraging.* Outside the Empire many countries are experimenting, the most important trials being in the Argentine, where round San Jose and Pindapay in Misiones there were some 50,000 trees. In Paraguay there are 30,000 trees. In conclusion *it is suggested that until tung oil can be proved capable of being successfully and profitably produced in any particular district*—and this must necessarily take some years to establish—*large scale plantings should not be undertaken* nor should the public be invited to subscribe funds.

3. Manuring.—from Hort. Absts. IV(1): 111. 1934.

In New Zealand methods of manuring are yet to be tested. In Florida a fertilizer containing 5% ammonia, 7% phosphoric acid, 2% potash is recommended to be applied twice yearly at the rate of 10-12 lb. per year per tree of 8-10 years, younger trees getting proportionately less. Green manuring is practised here with success. *Yield in commercial quantities should begin in the fifth year, increasing up to the twentieth* year. The return per acre is estimated at £25—£30 for the tenth year. It is also mentioned that the trees are self-fertile, that pests are unknown at present, that cattle will not eat the leaves (Indian cattle ?), and that high yielding strains can certainly be produced by budding. (*cf.* para 1 above, which suggests that high yielding strains can be grown from seed.)

ABSTRACT OF AN ARTICLE.

By C. J. McGregor.

East Afr. Agric. Jour. (1) : 127-30, 1935.

The article describes the cultivation of the tung oil tree *(Aleurites Fordii)* in Florida and Southern Georgia, United States of America at the present time. Propagation is by selected seed, though patch and ring budding in spring with buds of the current season have been successful. Cuttings have failed to root. The seedlings are raised in nursery rows and transplanted when a year old and from 3 to 6 ft. high to their permanent positions, the recommended spacing being about 30 ft. × 30 ft. The trees must be dormant at the time. The tree is a surface feeder so that cultivation is shallow and mulches are preferred. In established plantations the dense shade provided by the branches will keep the weeds in check. Low branching is desirable and, since many trees do not develop this habit naturally, it is produced artificially by cutting back the tree heavily when transplanting. The practice is also said to increase yield. Pinching the terminal bud merely causes the tree to throw further vertical growth. Branching is also produced by the removal of a strip of bark ½ inch wide and 1½ inches long just above the bud which it is required to start into growth. Cover crops of *crotalaria*, velvet beans and cowpeas planted a few feet from the trees between the rows are beneficial. The crop is gathered from the ground where it can safely be left for 2 or 3 weeks after the seeds have fallen in late autumn. Information as to the most suitable soil types is scarce, but the tree is suited to light, well-drained sandy loam with a slight acid reaction. The degree of acid tolerance is unknown. A pH of above 7 produced bronzing of the foliage while normal growth was maintained at pH 6·10. Excess of phosphate has also been found to be detrimental to growth. A study of the bud differentiation has shown that a season's crop is dependent on the tree being in thrifty condition the previous year, which necessitates the maintenance of a high soil fertility. That there may be a great difference between the yields of individual trees is shown by a test with only ten trees over 12 years in which two trees bore more fruit than the total yield from the remaining eight. The yield from 7-year-old tung trees under present conditions is 1,200 lbs. per acre. It is estimated that by topworking and an adequate fertilizer programme this would be raised to 1,800 lbs. per acre. To get profitable results it is necessary to treat the tree not as a forest tree but with the care accorded to a delicate, heavy yielding fruit tree.

Imp. Bur. Fruit Prod. Hort. Absts. V (4) : 681. 1935.

REPORT No. 1569/O.T. 35.

30th May 1935.

The following notes on the growing of Tung Oil trees may be of use.

Seed should be germinated in boxes or pits of sand. It is found that most rapid germination takes place if the temperature of the bed is maintained at 90-110°F during germination. This of course can only be done if the seed is kept in boxes suitably heated.

The germinated seed should be planted out in a well drained nursery, seed not closer than 8" apart. Light shade, about 5 ft. high is beneficial during the first few months. After 6 months in the nursery the average height should be about 18", and the plants can then be put out 20 ft. apart and protected by bamboo frames. It appears to be essential that drainage should be very efficient. Plants show ill effects from any water-logging of the soil. If the soil is good virgin soil there need be no manuring for a year or so at any rate. On poor old tea land, a manurial mixture should be given. A suitable mixture would be one supplying equal parts nitrogen, phosphoric acid and double the quantity of potash *e.g.*,

Nicifos 22/18	60%
Sulphate of potash	40%

Four ounces of the above mixture may be forked round each plant a foot from the collar, in the early spring.

The soil should be kept clean throughout the year for a space of a yard or so from the collar of the plant.

As regards pruning little need, or should be done, as the tree is being grown for fruit. The centre stem may be headed back when it has reached a height of 4 or 5 ft., in order to encourage spread of side branches (though it is not known whether this is a desirable procedure).

The tree flowers in the spring and fruit is ripe about the end of October. It can be allowed to fall, or can be shaken from the tree, but should not be plucked green.

Each fruit normally contains 3 to 5 nuts.

V

REPORT No. 3312/O.T. 35.

25th October 1935.

Cultivation of "tung" in Assam, with particular reference to its success at Tocklai Experimental Station.

(1) Trees were planted out in April 1928.

(2) Trees grew well at first and gave a little seed in their 2nd year. Since then, growth and production of seed has been disappointing. High winds and storms during March and April, when the trees are in flower, are responsible to a great extent for poor yields of fruit.

(3) At this Experimental Station only about 100 trees are in cultivation. Other areas, large and small are scattered over Assam and Bengal Dooars. The climatic conditions vary considerably over this area, rain-fall varying between 75 and 180 ins. The period however November to March is very dry, getting normally less than 5" of rain, while May to October is very wet. During the month of July, August and September there is no doubt that the moisture content of the soil is generally much above optimum. During the dry season November to April the temperature v aries between a maximum of about 85°F. and a minimum of about 40°F. In May and June the variation is from about 95°F to 75°F. During the rainy season July to October temperatures vary between about 90°F. and 78°F.

1. Species at this station are *A. Fordii* and *A. Montana* These are the species commonly found in the areas under cultivation in Assam and the Dooars.

2. Choice of land :—High well drained. In many cases areas of abandoned and uprooted tea have been used. The areas at this station are on poor soil, which previously carried light jungle.

3. Sowing :—Seed is germinated in boxes of moist sand, kept if possible at a fairly high temperature 90—100°F., at which temperature the seed normally germinates within two or three weeks, whereas at temperatures of about 80 F, or under germination may take several months.

Germinated seed is sown about 8" apart in well drained nursery beds. When plants are not less than 1 ft. high (after about 4-6 months) they are planted 20 ft. apart and protected by bamboo frames till they are 6 ft. or so in height. The soil for 3 ft. round the collar is kept clean by hand weeding and the remainder of the area by hoeing.

4. Manuring :—50 lbs. each of nitrogen, potash and phosphoric acid per acre has been applied in readily available form. Nitrogen as sulphate of

ammonia or nitrate of soda ; potash as sulphate of potash and phosphoric acid as superphosphate.

5. Harvesting :—At the time when fruit begins to fall from the trees (about the middle of September) men are sent round every week to shake the trees and to collect all fruit which has fallen. Fruit has all fallen by the end of October.

Yield :—This has been very poor for reasons given above. Even the best trees yielded only 7-10 lbs. of fruit in 1934, while the average was under 5 lbs.

Diseases :—Both *A. Fordii* and *A. Montana* have been found liable to root disease particulary when growing on land liable to waterlogging. Among the diseases found are *Fomes Lamaoensis ; Ustulina zonata ; Sphaerostilbe repens ; Diplodia* and *Fusarium spp.*

VI

REPORT No. 4/B.32.

April 16th 1932.

Variation in Tung Oil Plants.

Flowers.—The flowers are chiefly of interest to the Botanist on account of indications of a trimerous condition in a pentamerous structure. It is unnecessary to give here a detailed description of the morphology of the flowers.

The following account refers to variations in the different parts of the flowers.

Bracts.—About ¼ the length of the petals. Sometimes one only, which then almost completely encloses the base of the flower. Most commonly two bracts are present. Of this latter condition one bract is commonly larger than the other; the larger bract is frequently divided for a short distance below the apex: the smaller bract generally with an undivided apex. The bracts have dark brown prominently raised nerves, which usually total 5, *i.e.*, the larger (divided) bract usually possesses three, and the smaller bract two nerves.

Perianth.—White, prominent. The claw like bases of the perianth lobes are very thick, the centre part of each being prominently raised, with two less prominent lateral parts. Within, and at the base of the perianth lobes, are a number of small white linear scales. The base of each of these, at the point of attachment, is claw like and raised into three prominent ridges, sometimes with one or two additional subsidiary ridges. The upper liner part of the scale is undivided. The apex may be undivided, but more frequently is unequally divided for a short distance into two parts. A large centre part and two smaller and equal lateral parts is also a common condition.

Pistil.—Most frequently 5 partite with 5 bifid stigmas, but may be formed by the union of less or more than 5 carpels. The pistil does not vary much—I have observed 6 and 7 partite pistils, but variants more commonly have less than 5 parts. The most common variant is the 3 partite pistil, but even this is not very common and may be associated with young trees.

Male flowers.—Structure identical with that of the female flowers, except that the pistil is replaced by 10 stamens in two whorls of 5 each. The outer stamens are a little more than half the length of the inner stamens.

Inflorescence.—Both male and female flowers are present in the same panicles. The lowermost lateral members of a panicle may branch two or three times before apical growth is terminated by the formation of a flower bud. The main axis of the inflorescence is also terminated by a flower bud. Female flowers are nearly always terminal. There is a considerable amount of variation in the type of inflorescence, due to varying degrees of abortion of the male flowers. Between the two extremes of a predominantly female "cluster" and a predominantly male "cluster" are various intermediate types. In comparatively rare cases the male flowers of a panicle are almost entirely suppressed at the expense of one or more female flowers which terminate the main and lateral axes of the inflorescence. In such cases the female flower is borne on a short stout pedicel at the top of an axis which is shorter than usual. Arranged around the axis of the inflorescence below the female flowers are varying numbers of small linear bracts, in the axils of which are clusters of small aborted male flowers. Such male flowers are generally very small and inconspicuous, and show numerous degrees of abortion. Commonly they fail to shed pollen, or from between the minute sepals small stamens push out so that they are just uncovered—then a certain amount of pollen may be shed. There is a certain amount of variation amongst these clusters of small male flowers, so that the extreme variants approach the condition of normal development of the male flowers with few or no female flowers. With marked female development and reduction of the male flowers, variations may be noted —

(1) In the same inflorescence.

(2) Between different inflorescences on the same tree.

(3) Between different trees.

Thus all stages of abortion may be seen in the same inflorescence, but in general, the range of variation is less between male flowers within the same inflorescence, than that between flowers in different panicles on the same tree. Different trees are not identical with one another, and the average condition for panicles for each of a large number of individuals will form a general frequency curve for the species.

Abortion of male flowers is coincident with a shortening of the main axis of the inflorescence. The longer is the main axis the more flowers are there capable of producing pollen; the greatest reduction is near to the female flowers. In the typical female inflorescence there may be one or more female flowers, but most commonly one only. The most extreme case of female flower production is an almost complete supression of the main and lateral axes of the inflorescence, so that flowers are expanded only just above the level of the scales of the terminal bud.

Small variations in the inflorescence are the rule; extreme, variations, especially those which tend towards an entirely female cluster, are rare. The most common condition is undoubtedly a large number of well developed male flowers and an almost complete absence of female flowers. However, the condition may change with changing age of the tree. In the typical male panicle the bud terminating the main axis invariably drops off at a very early period of development (owing to the lateness of the examination, I have not been able to ascertain whether the bud is initially a male or female—I think the latter). The terminal bud of the lateral branches of the inflorescence may or may not drop off. If they do not drop off they are invariably males which are definitely smaller and weaker than the others. Of the panicles which are predominantly male, some will bear fruit, (developed from terminal flowers of the panicle); some trees however, bear solely male flowers. Panicles bearing fruit commonly show some reduction in the number and size of the male flowers. An extreme condition of this reduction is the typically female cluster with a few aborted male flowers.

Floral whorls—variation in the number of parts.—All the floral whorls generally consist of 5 members and there is little variation. Variations were noted in pistil, calyx and corolla. Any variation in the calyx is reflected in the corolla. Calyx and corolla variation is far more common in female than in male flowers. In female flowers 5—9 sepals and petals may be present; 7 is a fairly common variant, but this does not necessarily correspond with a similar variation in the parts of the pistil.

Pollination.—Very probably by means of insects. Two kinds of ants, numerous beetles, flies and bees visit the flowers. An interesting point is raised by the fact that the fruits have set and the petals of the female flowers fallen, before the majority of the male flowers open. Either the female flowers develop parthenogenetically or else the female flowers are fertilised with pollen from the very few male flowers which open at the same time as the female. On the other hand the high percentage of known female flowers which fall without setting fruit may be due to non-pollination. (On predominatingly female clusters the aborted male flowers may be responsible for pollination).

Leaves.—phyllotaxis is $\frac{2}{5}$. Youth forms are 3 lobed. Leaves on more mature growth are unlobed. As the tree become older the type of leaf changes, but youth forms tend to be produced at the beginning of a season. In *A Fordii* "youth" leaves are 3 lobed, the centre lobe being large and the two laterals small. Each lobe has a prominent mid rib, but in well developed leaves, 5 main veins may be distinguished, the two lowermost veins proceeding

to the periphery near to the base of the leaf. In *A. Montana* the "youth" leaves are 5 lobed and as the tree become older there is a transition to a 3 lobed type of leaf. The petioles and bases of *Montana* leaves are redder than those of *Fordii*. Nectaries are present on the leaves both of *Fordii* and *Montana*. Differences in these nectaries are very marked. In both species nectaries occur at the base of the leaf bla de, and if the leaf is lobed, nectaries are also present in the angles between the lobes of the leaf. At the base of the leaf at least two nectaries are present, both in *Fordii* and *Montana*. In *Fordii* 3—4 nectaries sometimes occur in this position. In each angle of the leaf only one nectary is present and this is always situated at a vein ending and on the lower side of the leaf. Nectaries in the angles of the leaf are not invariably present in *Fordii*—they are always present in *Montana*. *Fordii* nectaries are hemispherical with a minute depression in the centre (not generally noticeable without a lens) and of a bright reddish colour. *Montana* nectaries are deeply cup shaped, so that the contained nectar is visible to the naked eye; the nectaries are dull green in colour and stand out prominently from the petiole (and leaf) on a short green stem (the whole structure resembles the stem and bowl of a wine glass).

Three prominent leaf traces are associated with the leaf of *Fordii*. The two lateral traces are larger than the medium and appear (from a cursory field examination) to be composed each of two smaller traces.

Bud development.—Axillary buds are absent from the lower part of the seasons growth. Examination in the field failed to reveal any type of structure which might be classed as a dormant bud, either on the surface of the shoot or under the bark. There is probably a small amount of undifferentiated meristematic tissue at the old leaf axils.

Branching.—Lateral branches originate from the uppermost buds of a shoot towards the end of the season. If terminal growth ceases due to flowering, then a number of laterals grow out at the beginning of the season.

Type of tree.—Due to the fact that the only buds which develop are the uppermost ones (which are closely crowded together) and the fact that the stem may grow as much as 10′ in one season, the majority of the trees present a peculiar appearance: the trees are very "leggy" bearing at the top a system of "leggy" laterals. In cases where length growth has not been terminated by flowering the development of the laterals usually suppresses further growth of the leader. A few trees are branched from just above the ground level:, they are making shapely trees with a well spaced branch system. Apart from the fact that such trees bear a larger

number of flowers than the "leggy" type, the difference in branching is not associated with the most desirable flower characteristics. (Conversely, no other morphological feature was found associated with predominantly male or predominantly female clusters). Some trees had been decapitated at the same time as they were removed from the nursery. This had resulted in 2—3 laterals "breaking-away" but these laterals had failed to branch again and the resulting tree was simply a composite "leggy-type".

ABSTRACT

Selection problems of tung.

(Smolsky, N. V. Soviet Subtropics 1935: 4(8): 16-39)

No case of parthenocarpy has been observed, but upon occasion fruits have developed on *A. cordata* under conditions where all possibility of pollination was excluded, indicating that either parthenogenesis or apogamy had occurred.

Artificial self-pollination carried out in three forms of *A. Fordii* and one of *A. cordata* produced large numbers of fertile fruits, far in excess of those formed by trees left to pollinate naturally.

Imp. Bur. Plant Genetics. Plant
Breeding Absts. VI(4): 1934. 1936.

cf. the Botanist's memorandum of March 1932 where it was suggested (1) that parthenogenesis may occur in *A. Fordii* and (2) that, on the other hand, the failure of numbers of female flowers (of *A. Fordii*) to set fruit may be due to non-pollination.

VIII Species of "Aleurites" "(tung)".

"Tung" is the name now commonly applied in Assam to *Aleurites Fordii* and to *Aleurites Montana*: It is however recognised that the two are not the same and that each produces a different kind of oil *i.e.* common usage at present recognises two distinct kinds of "tung". Some would restrict the term "tung" to *Aleurites Fordii*[1] (to which it certainly does apply): it would than be better to use some other term, such as "Mu-yu" for *A. Montana*—"Mu-yu", and "abrusin" oil are terms which have already been applied to the oil of *A. Montana*. Popular usage in Assam at the moment tends to quite wrongly refer to all *Aleurites* as "tung", each of the five species of *Aleurites* thus becoming a different "variety" of "tung" (it should be noted that "variety" here has no more than a popular significance and is scientifically meaningless.) Attention should, however, be paid to recognised terminology as "tung" is already an established article of commerce.

The following notes on the species of *Aleurites* may be helpful to those interested in the culture of "tung".

The genus *Aleurites* belongs to the family *Euphorbiaceae*, It is a genus foreign to India proper (*i.e.* excluding Burma) though two species (*A. triloba* Forst. and *A. cordata* Steud) have been introduced for fifty years at least and one (*A. triloba* Forst.) is naturalised and grows wild in the Wynaad[2]. *A. Fordii* and *A. Montana* have been extensively introduced into India only during the last decade in in connection with an Empire development scheme. The nearest relations to *Aleurites* in the indigenous flora are *Jatropha*, *Tritaxis*, and *Croton*.

(1) *A. FORDII.* Hemsl. –the tung tree: tung oil proper is derived only from the seed of *A. Fordii.*[3] Native of China: grows in the Yangtze Valley. A sub-tropical rather than a tropical tree.[3]

(2) *A. MONTANA.* E. H. Wilson.—A native of S. E. China, extending into French Indo China and the Shan States of Burma. A tree of the tropics; probably requires a heavier hot weather rainfall than *A. Fordii.*[3] *A. Montana* yields "Mu-yu" oil[4] (also known as "Abrasin oil")[5] which, though different from tung oil, is suitable for varnish making

[1] Imp. Agric. Bur Hort. Absts. V(2): 275. 1935.

[2] *cf.* Hooker. Flora Brit. India. Vol. 5. pp. 239; 385. 1890.

[3] Imp. Agric. Bur. Hort. Absts. V(2): 275. 1935.

[4] The Production of Tung Oil in the Empire. H. M. Stationery Office Lond. E M. B. 31. June, 1930.

[5] Imp. Agric. Bur. Hort. Absts. V(2): 275. 1935.

purposes.[6] The oils of *A. Montana* and *A. Fordii*, sometimes indiscriminately mixed, are exported from China under the name of Chinese wood oil[1] (or *sometimes simply as* "Wood Oil"): the two *oils*, similar, but not by any means indentical have acquired the common name of "tung"[7], the specific name of the plant in parenthesis serving, when necessary, to identify the one kind of "tung" from the other.

There are three other species of *Aleurites* which also bear oil yielding seeds. Their oils have not the same special properties as those of *A. Fordii* and *A. Montana* and cannot replace them in the paint and varnish trade.[8] They are as follows:—

A. CORDATA. Steud.—A native of China and Japan. This is the source of Japanese wood oil or Japanese tung oil and has been regarded by Russian workers as worth experimental cultivation.[9] *A cordata* can be cultivated in the sub tropics. The following abstract[10] will give some idea of the cultivation of the tree in Japan.

> *Motte, J.*
> *L'Aleurities cordate au Japan. (Aleurites cordata, the Japanese wood oil tree in Japan.)*
> *Agron. Colon., 1935, 24: 210: 183-93. and 211: 7-15.*

This tree, a native of Japan, is not geographically widely distributed in that country and it is difficult to distinguish original wild from planted stands, since all are now exploited and regularly cultivated. It is chiefly found in the province of Hondo growing on the lower mountain slopes where the soil is deep and humid and precipitation high. A full botanical description of the tree is given. It is said to resemble closely *A. Montana*. While the tree may be considered to be definitely monoecious there is nevertheless a tendency for one or other of the sexes to predominate on certain trees, which then become easily distinguishable. A tree in which the male flowers preponderate is larger, less branched, and of quicker

[6] Jordon. Journ. Royal Soc. Arts. LXXXIII (4320): 555. 1935.

[7] Dr. Jordon of the British Paint Colour and Varnish Manufacture Research Association, speaks of "Tung oil trees (referring to the species *Aleurites Fordii* particularly and to *A. Montana* in a less degree)" and again "Reference has only been made to "tung oil", referring to the product of the two species *Aleurites Fordii* and *Aleurites Montana*". (Jordon. Tung Oil. *Journ. Oil & Colour Chemists Association XII : 197 : 1929.*)

[8] The Production of Tung Oil in the Empire. H. M. Stationery Office Lond. E. M. B. 31. June 1930.

[9] Imp. Agric. Bur. Hort. Absts. II(1) : 72. 1932.

[10] Imp. Agric. Bur. Hort. Absts. V(3) : 457. 1935.

growth. The leaves are lobed and the flowering later. The tree with mainly female flowers is dwarfer, bushier, of relatively slow growth, and has rounder leaves. In neither case is the dioecism ever absolute. Possibly it is a varietal difference. Propagation is effected by seeds. Seed is sown either in autumn as soon as gathered in mild districts, or after stratification in spring where the climate is colder. Seeds will retain their vitality for two years. The seeds are placed in water just before planting, only those which sink being used, and from these a germination of 90%—100% is obtained. A year later the seeds are pricked out into nursery beds, the final planting being made the following spring. The original density is 800 per hectare reduced by gradual elimination of weakly, male, or otherwise imperfect trees to 200 per hectare. A method of detecting the stronger growing male trees in the seed bed is to put down straw mats at a certain depth below the soil in which the seeds are to be sown and to reject at transplanting all those whose roots have passed through the mats. Trees come into bearing when 7 to 10 years old, but the first harvest is not usually made until the 12th or 13th years. At 50 years old the trees are cut down and the wood applied to various industrial uses. The method of harvesting consists in picking up the fruits off the ground either as they fall or in two gatherings at 10 days intervals. The seeds are depulped by fermentation or if old by pounding in a mortar, usually with a straw mat at the bottom. The oil is extracted by expression after desiccation, the yield being about 1·7 litres per 10 litres of seed. Two expressions are made and their oils mixed. The mixture is clarified by settling, and is then ready for sale.

(4) *A. TRILOBA*. Forst (= *A. moluccana* Willd.) This is the Brazilian candleberry (or candlenut) tree and yields Candlenut or lumbangoil (also known as bancoulier oil[11]). The oil of this tree is used for soap making and attempts have been made to utilise it in many other directions.[12] *A. triloba* requires tropical conditions.

(5) *A. TRISPERMA*. Blanco. The oil of this is known as "soft lumbang (as opposed to the "lumbang" of *A. triloba*.) According to one rather old report[13] the oil of *A. trisperma* is an excellent drying oil. It has, however since been authoritatively stated that no other species of

[11] Imp. Agric. Bur. Hort. Absts. V(2) : 275. 1935.

[12] Imp. Agric. Bur. Hort. Absts. IV(2) : 271. 1931.

[13] Bot. Absts IV 1) . 307. 1920

Aleurites can replace *A. Fordii* and *A. Montana* in the paint and varnish trade.[14] *A. trisperma* requires tropical conditions of growth.

The possibilities of crosses between the species of *Aleurites* should be explored as soon as possible. The cross[15] *A. Fordii* × *A. Montana* is being investigated at the University of Florida.

[14] The Production of Tung Oil. in the Empire. H. M Stationery Office Lond. E. H. B. 31. June 1930.

[15] Jordon. Tung Oil. Journ. Oil & Colour Chemist Assoc. XII(107). 1929.

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